MANUAL NO. 997-045924-001

OWNERS and SERVICE MANUAL for

moog® MEMORYMOOG

MODEL 345

This binder contains the complete owners and technical manuals for the Memorymoog. As updates and improvements are made in the instrument, they will be described in the Addenda section in the back of the manual.

MEMORYMOOG OWNERS MANUAL

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INTRODUCTION

The Memorymoog is a voice-assignment polyphonic synthesizer with the ability to store up to 100 patches in computer memory. It has six independent voices, each containing three voltage-controlled oscillators, a voltage-controlled 24dB/octave lowpass filter, two ADSR contour generators, and extensive modulation facilities. This means that there are 18 oscillators, six filters, and 12 contour generators in the unit. However, there is a single set of controls for those components, meaning that their sound is programmed homophonically — each program governs each voice identically.

At the heart of the Memorymoog is the System Controller which gives you command over the instrument's microprocessor. With the System Controller you can change programs, store patches, change keyboard modes, use the cassette interface, alter arpeggiation mode, and set up program sequences. Learning to use the System Controller is the key to learning how to use the Memorymoog.

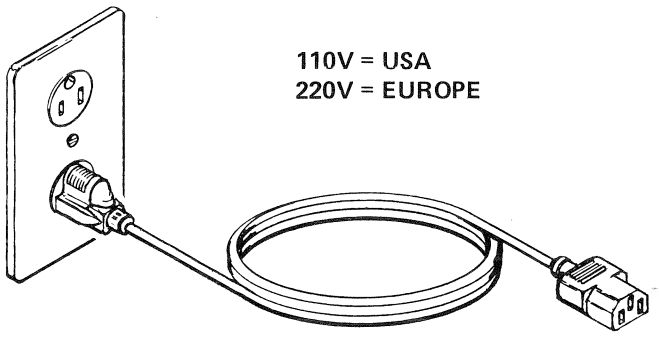
This manual is designed in sections, starting with a quick setup guide for those of you who are in a hurry to quit reading and start playing. It tells you some dos and don'ts about setting up and explains what you'll need to know about the System Controller in order to get at the programs. Section II is a reference guide designed to help answer any questions regarding specific features on the Memorymoog. Section III is a step-by-step explanation of each set of controls for those of you who aren't all that familiar with synthesis. It's designed to help clarify things that may seem vague in Section II. The final section of the manual deals with service information and contains schematics and maintenance details. A sound chart section is included that contains diagrams of all the factory programs. Some blank panel diagrams are also provided for you to copy down your own patches.

SECTION I

SETTING UP

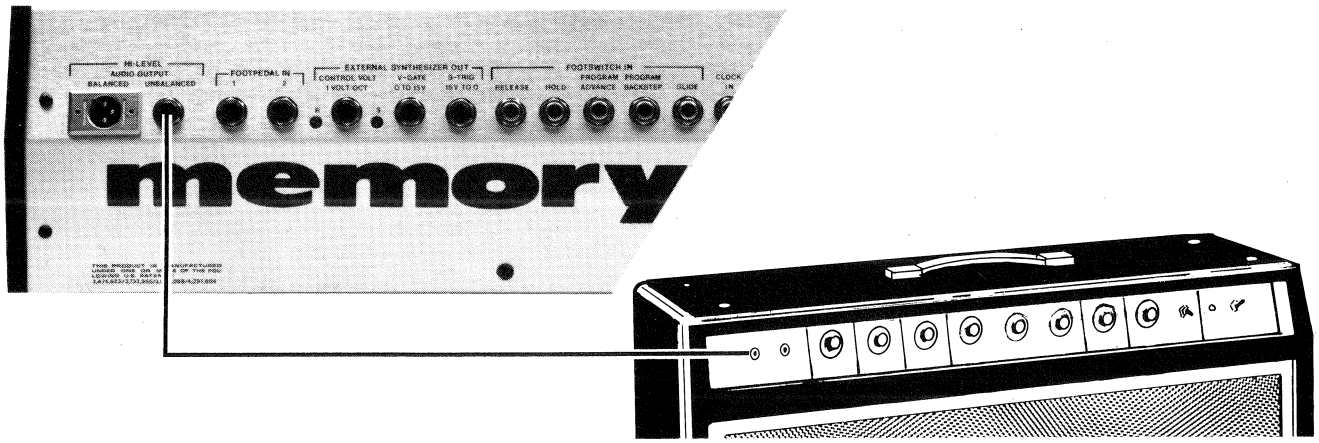
If you haven't bought a flight case for your Memorymoog, save the carton it came in in case you have to arrange long distance transportation.

After unpacking your instrument, hook it up to a wall socket by first inserting the detachable three-pronged cord into the back of the Memorymoog and then into the power outlet. Be sure that the outlet is putting out the right amount of voltage.



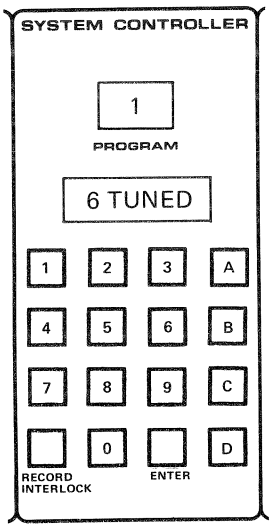
If you want to operate your Memorymoog on a voltage that differs from what's coming out of the wall socket, i.e. 220 instead of 110 or 110 instead of 220, an authorized Moog service center can set up your instrument to operate at the proper voltage.

Next hook any footpedals or switches you desire to use up to their respective inputs. Then connect the audio output of the Memorymoog to an amplification system using either an XLR cable or a 1/4" phone jack. A high quality amp is desirable due to the wide frequency range of the Memorymoog. Also, note that different amps will make the programs sound different.



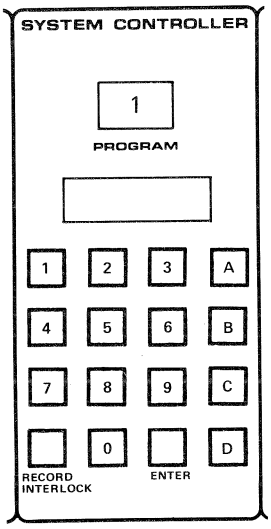
Turn the output volume of both the Memorymoog and the amp down to zero. Turn the Memorymoog on and then turn the amp on.Bring the volume of the amp up to where you're used to setting it. While holding down a note, bring the MASTER VOLUME control (at the upper right corner) up until it's at a comfortable level.

After you've turned the instrument on, let it warm up for about 10 minutes to allow the oscillators to stabilize. Then hit the AUTO TUNE control in the upper left-hand corner. This will tune the Memorymoog's 18 oscillators. Notice that the SYSTEM CONTROLLER's Alphanumeric Display reads "6 TUNED" after the tuning cycle is complete, indicating that all six voices have been tuned. If a number less than six appears in the screen, it means that the system was unable to tune one or more of the oscillators for some reason. Try hitting the AUTO TUNE switch again if this occurs. If they still fail to tune, they can be manually disabled. Refer to the Service Section of the manual for details.



CALLING UP PROGRAMS

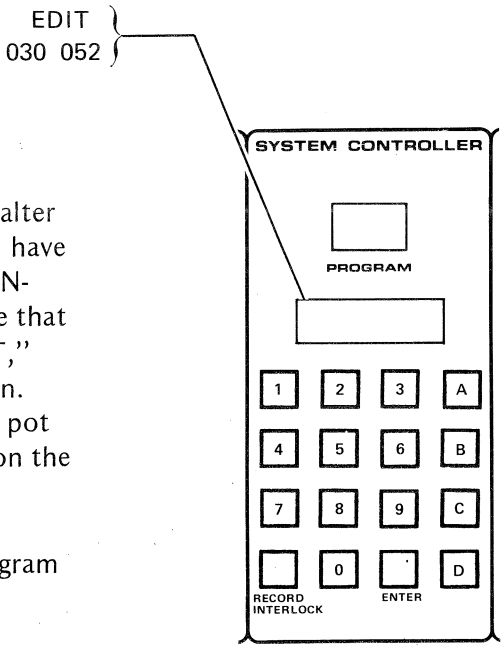
When you first turn the Memorymoog on, program Number 1 will appear in the PROGRAM DISPLAY window of the SYSTEM CONTROLLER. To change program numbers, hit any number from 0 to 99 followed by hitting the ENTER button on the Numeric Keyboard of the SYSTEM CONTROLLER.



EDITING A SOUND

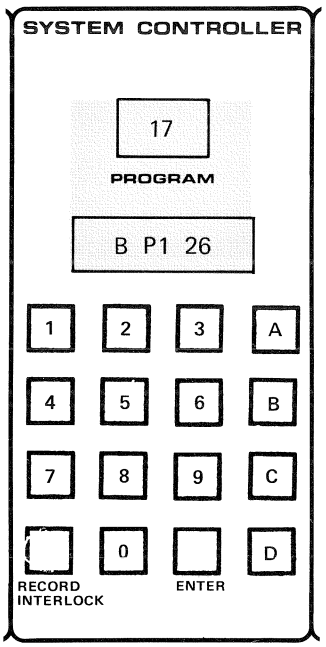
Changing or editing programs is very simple. If you want to alter some aspect of any of the sounds supplied by the factory, all you have to do is hit any of the switches (except those in the SYSTEM CONTROLLER) or hit any of the rotary controls (pots). You'll notice that when you hit a switch the Alphanumeric Display will read "EDIT," and when you turn a pot, six numbers appear in the display screen. The group of three numbers on the left indicates the value of the pot as it is in the program memory, and the group of three numbers on the right indicates the current value of the pot.

Hitting the ENTER button will immediately restore the program values.



CALLING UP AND STEPPING THROUGH PROGRAM SEQUENCES

To get into the PROGRAM SEQUENCE MODE hit PREFIX letter D, followed by any number from 0 to 9, followed by ENTER. This gets you to one of the 10 PROGRAM SEQUENCES. What will appear in the Alphanumeric Display looks like this:



The number in the PROGRAM DISPLAY is the first program of the PROGRAM SEQUENCE. The B at the left of the screen indicates the beginning of the SEQUENCE. As you step through the SEQUENCE, the number that appears in this spot indicates the previous program number. The center of the display shows the PROGRAM SEQUENCE number, and the number to the right of the screen is the program number next in line in the SEQUENCE.

To step through the PROGRAM SEQUENCE, use the A PREFIX switch to go forward and the B PREFIX switch to go backward. You can also use PROGRAM ADVANCE and PROGRAM BACKSTEP footswitches for these functions. (Note that the footswitches aren't supplied with the instrument.)

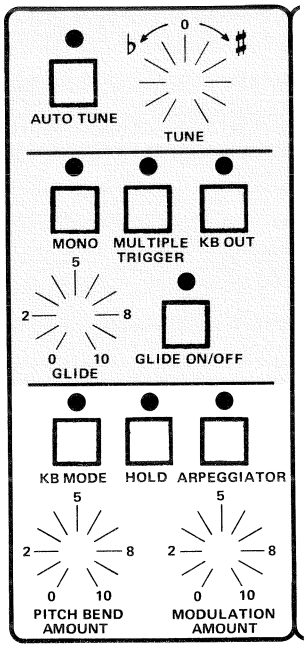
Experimenting with the programs, editing them, and stepping through the PROGRAM SEQUENCES should keep you busy for at least a few minutes. It should also start generating questions about other features on the instrument. Section II of the manual provides brief descriptions of all the various functions of the Memorymoog, while Section III offers step-by-step explanations. From this point, refer to those sections as the need arises.

SECTION II

This section of the Memorymoog manual is designed to answer questions about the function of each control on the front and back panels of the instrument. It's a quick reference guide; more detailed explanations will be found in the next portion of the manual.

1.0 KEYBOARD/PERFORMANCE CONTROLS.

1.1 AUTO TUNE.
Touching this switch causes the computer in the unit to tune the 18 oscillators. Tuning takes about 8 seconds. The instrument will be "dead" for that period of time. The SYSTEM CONTROLLER's (3.0) Alphanumeric Display will show "TUNING" when the switch is initially depressed, and it will show how many voices have been tuned at the end of the tuning cycle.



1.2 TUNE.
Lets you fine tune the instrument over a range of ± 3 semitones. This is a non-programmable control and will affect all voices identically.

1.3 MONO.
This switch puts the instrument into the monophonic mode — it will play only one key at a time. The number of voice cards you control is variable from 1 up to 6, giving you control over from 1 to 18 oscillators. This is programmed by the SYSTEM CONTROLLER (3.0) and the MIXER section (7.0).

1.4 MULTIPLE TRIGGER.
When on, the keyboard triggers all contours when any new keys are depressed. When off, new notes trigger only the assigned voice.

1.5 KB OUT.
KEYBOARD OUT controls the trigger and voltage outputs from the EXTERNAL SYNTHESIZER OUTPUT section (14.0). It's used when controlling an external synthesizer. When on, the Memorymoog will control the external synthesizer.

1.6 GLIDE AMOUNT AND GLIDE ON/OFF.
The glide is both monophonic and polyphonic. When the instrument is in mono mode, a master glide circuit takes over for the 6 separate glide circuits that work when it's in polyphonic mode, and allows the instrument to glide in unison. Glide is linear. Maximum glide time between the outer notes of the keyboard is about 10 seconds.

1.7 KB MODE.

KEYBOARD MODE affects the priority of the keyboard when it's in both mono and polyphonic modes. In mono mode, the SYSTEM CONTROLLER (3.0) Alphanumeric Display shows either "MONO 1, 2 or 3," depending on the mono mode programmed. Mono 1 is last-note priority, Mono 2 is low-note priority, and Mono 3 is high-note priority. In polyphonic mode, the Alphanumeric Display will show either "POLY 1" (cyclic), "2" (cyclic with memory), "3" (reset to voice A), or "4" (reset to voice A with memory). Voltages routed to an external synth via the EXTERNAL SYNTHESIZER OUTPUT (14.0) are affected by this control.

1.8 HOLD.

Lets you build up chords and transpose them in parallel motion from the keyboard. Holding a chord and then pressing the HOLD button will memorize the chord. Holding down the HOLD button and then pressing notes on the keyboard will let you build widely spaced chords. Releasing the HOLD button memorizes the chord. The chord can then be transposed from the last note you played on the keyboard.

1.9 ARPEGGIATOR.

Continuously triggers note played on the keyboard. Rate is set by the LFO (5.0) speed. The Clock can be overridden by an external trigger source at the CLOCK IN (15.5) on the back panel. The internal clock is reset by the keyboard so you can always play in time. The Arpeggiator operates in six different modes:

1) Plays back notes from bottom to top, unlatched (notes stop when you lift off the keyboard).

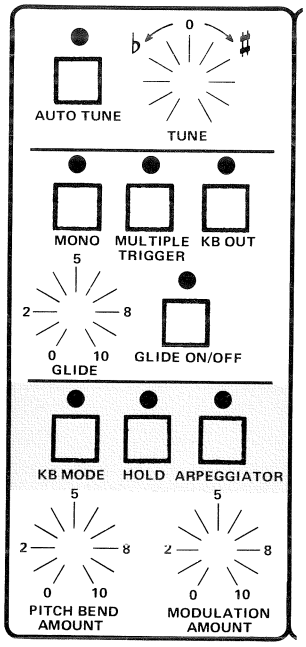
2) Plays back notes from top to bottom, unlatched.

3) Plays back notes from top to bottom, and then from bottom to top, unlatched.

4) Plays back notes from bottom to top (latched). The notes will continue if you lift your hands off the keyboard.

5) Plays back notes from top to bottom, latched.

6) Plays back notes from top to bottom, and then from bottom to top, latched.

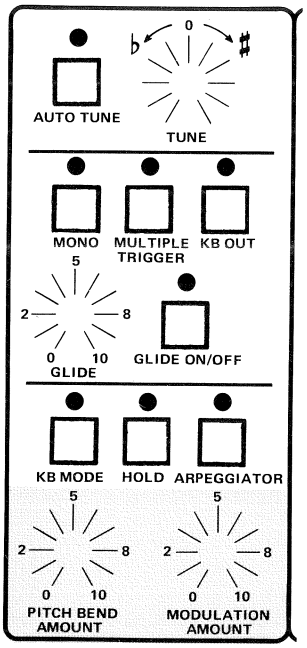


1.10 PITCH BEND AMOUNT.

Lets you vary the maximum range of the PITCH BENDING WHEEL (2.2) up to ± 1 octave. Note that this control is programmable.

1.11 MODULATION AMOUNT.

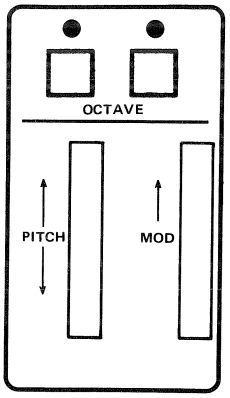
Sets a programmable initial modulation amount. The MODULATION WHEEL (2.3) adds to the amount set by this control.



2.0 LEFT-HAND CONTROLLERS.

2.1 OCTAVE SWITCHES.

These are not programmable. They raise or lower the pitch of all oscillators by one octave.



2.2 PITCH WHEEL.

Lets you bend the pitch of what's played on the keyboard by an amount determined by the PITCH BEND AMOUNT control (1.11).

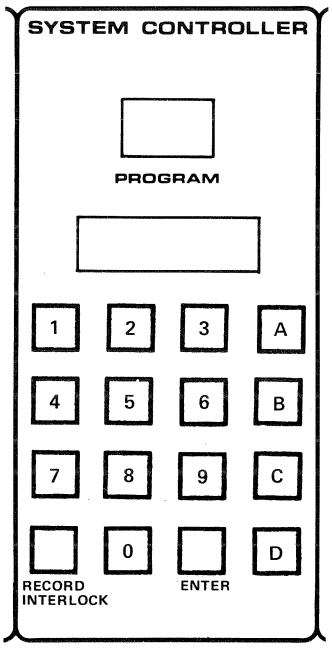
2.3 MODULATION WHEEL.

For injecting modulation from the LFO (5.0). Adds to the initial amount of modulation programmed by the MODULATION AMOUNT control (1.12).

3.0 SYSTEM CONTROLLER.

3.1 PROGRAM DISPLAY.

The large numeric LED (Light Emitting Diode) display shows which program number has been called up. Program numbers range from 0 to 99.



3.2 ALPHANUMERIC DISPLAY.

Through this display, the Memorymoog's computer conveys various sorts of information about what is going on in the instrument. When the AUTO TUNE cycle is complete, it will display how many voice cards have been tuned up by showing "1, 2, 3, 4, 5 or 6 TUNED." Note that any number less than 6 indicates that the computer couldn't tune one of the voice cards for some reason.

If you change any part of the current program in the display by activating a control pot or switch, it will read "EDIT." If you've changed a rotary pot's position, the left side of the display will show the value of that pot as it is in memory, while the right side displays the current value. With this readout, you can match old programs or return a pot to its original value.

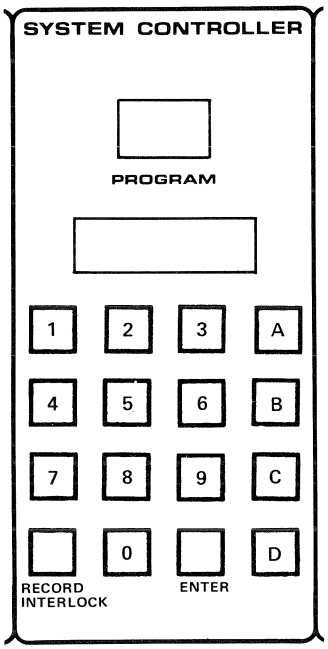
Keyboard mode is indicated on the Alphanumeric Display when you hit the KB MODE switch (1.7). When the RECORD INTERLOCK button (3.4) is hit, the display will read "LOCK." When a program has been recorded into memory the display will read "RECORDED."

3.3 NUMERIC KEYBOARD.

This calculator-type keyboard is used for calling up programs and other control functions. You do this by hitting one or two numbers (from 0 to 99) and then pressing the ENTER button.

3.4 RECORD INTERLOCK.

This switch is used to temporarily lock the front panel settings in memory. By hitting LOCK, the Alphanumeric Display (3.2) will read "LOCK," indicating that the current panel settings are temporarily locked, and turning pots or hitting switches will have no effect. This allows you to call up another patch from memory (by hitting a number and pressing ENTER) without losing the locked patch. Hitting the LOCK switch after you've called up another patch will bring up the locked patch. This is useful for checking edited patches against the original version.



3.5 STORING A PATCH IN MEMORY.

This is done by holding the LOCK button (3.4) down and hitting the ENTER button (see 3.3). This loads whatever is currently shown on the front panel into the memory position called up in the Program Display (3.1). Note that recording a patch is impossible if the Memorymoog is "write disabled," meaning that a protect function against storing unwanted information in memory is on. To turn the protect function off and on, you must know the four-digit security code (see Section III). Attempting to store a patch in memory when the disable feature is on will cause the Alphanumeric Display (3.2) to read "DISABLED." When a patch has been successfully written into a memory position the Alphanumeric Display will read "RECORDED."

3.6 PREFIX BUTTONS.

PREFIX A advances programs stored in the PROGRAM SEQUENCE MODE (see below). Also advances program number by one in normal operating mode.

PREFIX B steps in reverse through the programs in the PROGRAM SEQUENCE MODE (see below). Backsteps program number by one in normal operating mode.

PREFIX C1 *(hit C, hit 1, hit ENTER)* saves programs onto cassette tape (for more information on this procedure see the next section of the manual).

PREFIX C2 *(hit C, hit 2, hit ENTER)* loads programs from cassette tape into the Memorymoog's memory.

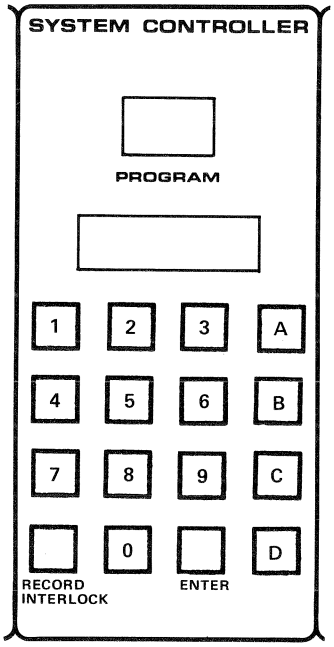
PREFIX C3 *(hit C, hit 3, hit ENTER)* verifies correct loading of programs when putting programs from the Memorymoog onto cassette tape.

PREFIX C4 is used for defeating voices that aren't tuning up for whatever reason. See text in next section of the manual for details.

PREFIX C5 tunes all oscillators to unison, regardless of front panel settings.

PREFIXES C6 and **C7** are electronic tuning aids for service technicians.

PREFIX C8 displays current memory status, ENABLED or DISABLED in the Alphanumeric Display (3.2). The unit powers up with the memory disabled so that you can't accidentally record a patch and you can't use the cassette interface functions of PREFIXES C1, 2, and 3. To enable the memory store function, hit C8 followed by the four-digit security code (see Section III). Hitting the letter C after entering C8 tells the instrument that you want to change the security code. Do this by entering the old four-digit code (the code of instruments fresh from the factory is 0000); the display will read "NEW CODE" or "BAD CODE" depending on if you have it right or not. If the old code is correct, you may then enter any new four-digit code.

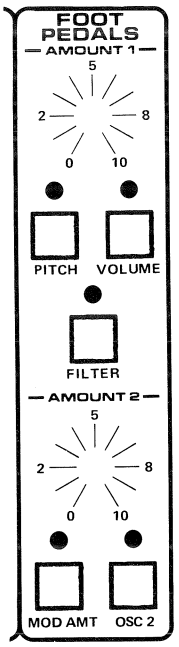


PREFIX C9 makes the front panel live. The Alphanumeric Display (3.2) will read "LIVE PNL" when you hit C, hit 9, hit ENTER. In this state, the front panel controls override the memory settings.

PREFIX C0 flashes all the LEDs. This is another service function to check if all the LEDs work. Hitting any switch turns the function off.

PREFIXES D0 to **D9** call up PROGRAM SEQUENCES. These are chains of up to 20 programs, each arranged in some predetermined order. To call one up hit D, hit a number from 0 to 9, and hit ENTER. To load a PROGRAM SEQUENCE, hit D, hit D again, hit a number from 0 to 9 and hit ENTER to get into PROGRAM SEQUENCE LOADING MODE. Then to enter programs, hit the program number, hit ENTER, hit A (ADVANCE switch) or B (BACKSTEP switch). Repeat until you've loaded all the programs you require. The loading mode will stop after 10 programs are loaded. You can also use the ADVANCE and BACKSTEP footswitches (15.3 and 15.4) to step forward and backward in the PROGRAM SEQUENCE.

4.0 FOOTPEDALS.



4.1 AMOUNT 1, PITCH, VOLUME, FILTER.

The AMOUNT knob controls the overall range of footpedal number 1 which can be routed to control the pitch of all the oscillators, the volume, and the filter's cutoff frequency. Functions are programmable.

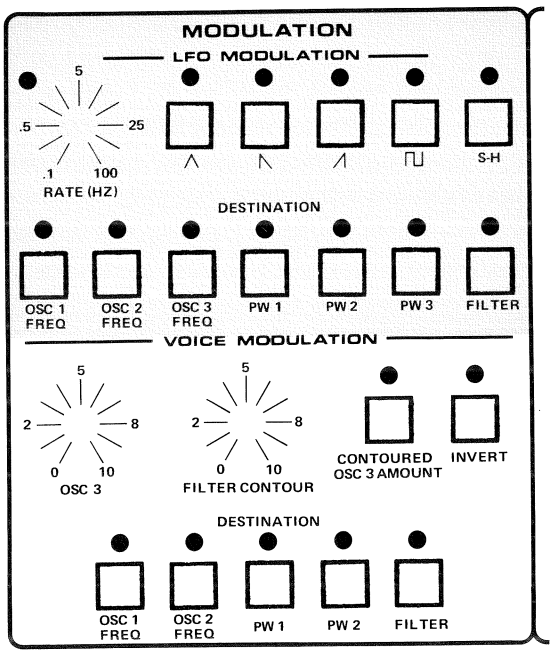
4.2 AMOUNT 2, MOD AMT, OSC 2.

Determines the range of a second voltage pedal which can be routed to control the amount of modulation and/or the frequency of the second oscillator.

NOTE: Footpedals are not supplied with the instrument. The inputs on the back panel (13.0) will use any voltage input that ranges from 0 to 5 volts. If you plug in just one pedal, the input will crosscouple so that one footpedal will control whatever is called up on either PEDAL 1 or PEDAL 2's programs.

5.0 LFO MODULATION.

The amount of modulation is controlled by the MODULATION AMOUNT knob (1.12) and the MODULATION WHEEL (2.3).



5.1 RATE (HZ).

Controls the LFO frequency. Variable from .1Hz to 100Hz.

5.2 WAVESHAPE SELECTION.

Five switches to the right of the RATE (5.1) knob for selecting triangle, positive-going sawtooth, negative-going sawtooth, square, or sample-and-hold waveshapes for the low frequency oscillator. Selecting one waveshape excludes the others; waveshapes can't be intermixed.

5.3 DESTINATION SWITCHES.

The output of the LFO can be routed to seven places. It can be used to modulate the frequencies of oscillator 1 (OSC 1), oscillator 2 (OSC 2), oscillator 3 (OSC 3), the pulse width of oscillator 1 (PW 1), the pulse width of oscillator 2 (PW 2), the pulse width of oscillator 3 (PW 3), and/or the filter's cutoff frequency.

5.4 VOICE MODULATION.
The source of this modulation is selectable from either the filter's contour generator or the third oscillator. These affect each voice independently. Voice Modulation is independent of the LFO Modulation (5.0).

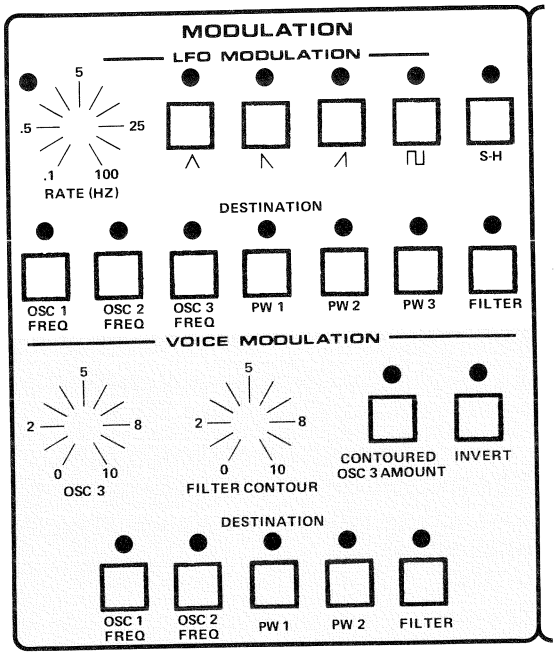
5.5 OSC 3.
Controls the amount of modulation from oscillator 3.

5.6 FILTER CONTOUR.
Controls the amount of modulation from the filter's contour generator.

5.7 CONTOURED OSC 3 AMOUNT.
When switched on allows the filter's contour generator to shape the amount of modulation coming from oscillator three. This is useful for creating modulation effects that vary with time.

5.8 INVERT.
Inverts the filter contour as it's applied to the CONTOURED OSC 3 AMOUNT (5.7) and inverts the output of OSC 3 (6.0).

5.9 DESTINATION SWITCHES.
Voice Modulation can be routed to five places using this set of switches: the frequency of oscillator 1 (OSC 1 FREQ), the frequency of oscillator 2 (OSC 2 FREQ), the pulse width of oscillator 1 (PW 1), the pulse width of oscillator 2 (PW 2), and/or the filter's cutoff frequency (FILTER).



6.0 OSCILLATORS.

6.1 OCTAVE (oscillators 1, 2, 3).
16', 8', 4', and 2' octave settings for each oscillator are available via these switches. Note that the octave switches in the LEFT-HAND CONTROLLER section (2.0) will raise or lower the pitch of the oscillators one octave.

6.2 SYNC 2 TO 1 (oscillator 1 only).
Locks the fundamental frequency of oscillator 2 to that of oscillator 1. It is hard sync.

6.3 PULSE WIDTH (oscillators 1, 2, 3).
Varies the width of the rectangular waveshape from 0 to 100%. At the outer extremes of this range the pulse width will be so narrow that you won't hear any signal.

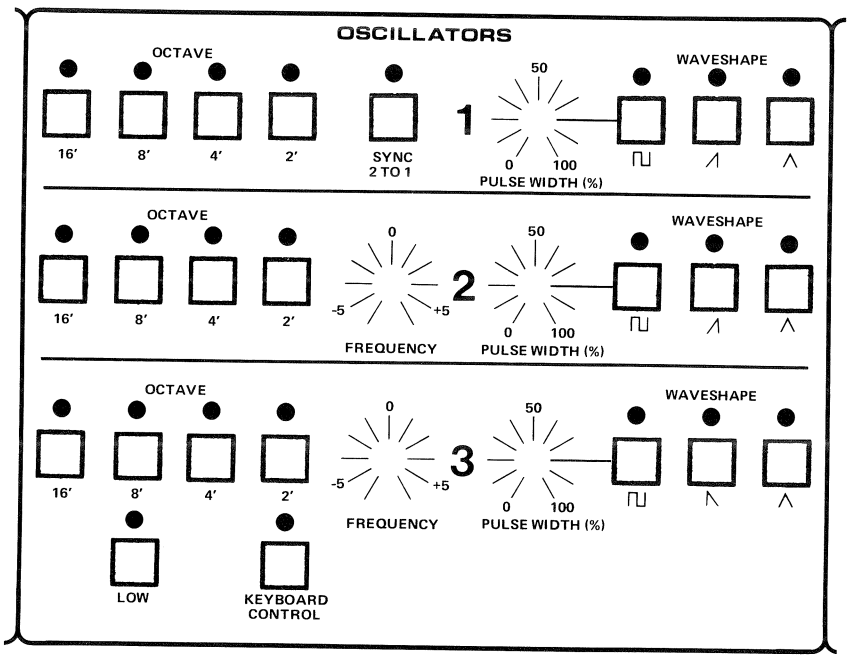
6.4 WAVESHAPES (oscillators 1, 2, 3).
These three switches let you call up pulse, sawtooth, and/or triangle waveshapes. Waveshapes can be combined.

6.5 FREQUENCY (oscillator 2).
A dual concentric pot which lets you tune the second oscillator ± a minor sixth. The outer ring is for coarse control and the inner ring is for making finer adjustments.

6.6 FREQUENCY (oscillator 3).
Tunes the third oscillator ± a minor sixth. However, when the KEYBOARD CONTROL switch (6.8) is off or the LOW switch (6.7) is on, the range of this knob is increased to 2-1/2 octaves.

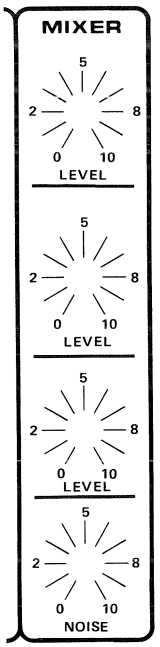
6.7 LOW (oscillator 3 only).
Drops the frequency of oscillator 3 by approximately 5 octaves, converting it to a low frequency oscillator. With this switch on, the range of the FREQUENCY control (6.6) is increased to 2-1/2 octaves.

6.8 KEYBOARD CONTROL (oscillator 3 only).
For turning on and off the keyboard control voltage routed to oscillator 3. With the keyboard control voltage off, the range of the FREQUENCY control (6.6) is increased to 2-1/2 octaves.



7.0 MIXER

Four level controls for adjusting the relative volumes of the three oscillators and a pink noise source as they feed into the filter. Note that beyond a setting of 4 or 5, these controls cause the signals to clip (distort). This gives a little more punch to a sound where desired. It also turns the triangle waves into sine waves. At a setting of 10 you will hear some intermodulation distortion.



8.0 VOLTAGE CONTROLLED FILTER.

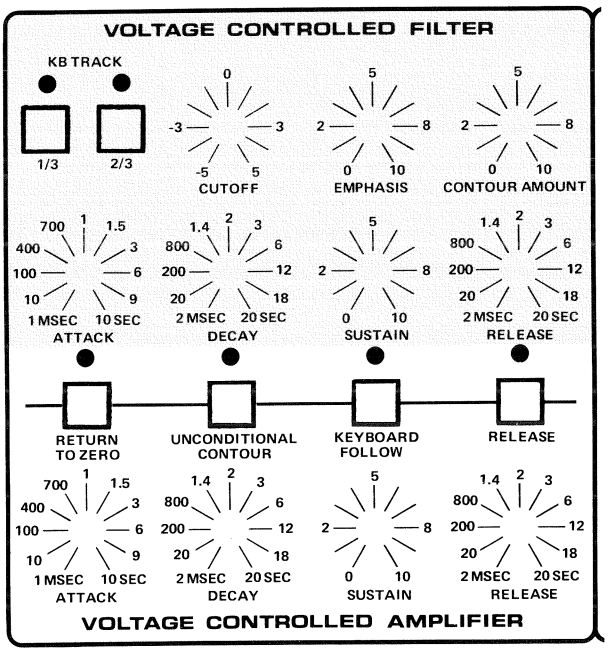
The Voltage Controlled Filter is the patented Moog 24db/octave lowpass filter.

8.1 KB TRACK.

Varies the amount of voltage from the keyboard that controls the filter cutoff frequency. You can select either 1/3 of the keyboard voltage, 2/3 of the keyboard voltage, all of the keyboard voltage (both switches on), or no keyboard voltage (both switches off).

8.2 CUTOFF.

Controls the cutoff frequency of the filter.



8.3 EMPHASIS.

Controls the degree of filter resonance. Oscillation begins at a little past a setting of 7.

8.4 CONTOUR AMOUNT.

Controls the amount of voltage from the FILTER CONTOUR GENERATOR (8.5) that is applied to the cutoff frequency.

8.5 FILTER CONTOUR GENERATOR.

8.6 ATTACK.

Varies the attack time from 1 millisecond to 10 seconds.

8.7 DECAY.

Variable from 2 milliseconds to 20 seconds.

8.8 SUSTAIN.

Varies the sustain level of the filter contour.

8.9 RELEASE.

Adjustable from 2 milliseconds to 20 seconds. The RELEASE SWITCH (10.4) and/or the RELEASE FOOTSWITCH (15.1) turn the release portion of the contour on and off.

9.0 VOLTAGE CONTROLLED AMPLIFIER.
An ADSR contour generator controls the VCA.

9.1 ATTACK.
Same as section 8.6.

9.2 DECAY.
Same as section 8.7.

9.3 SUSTAIN.
Same as section 8.8.

9.4 RELEASE.
Same as section 8.9.

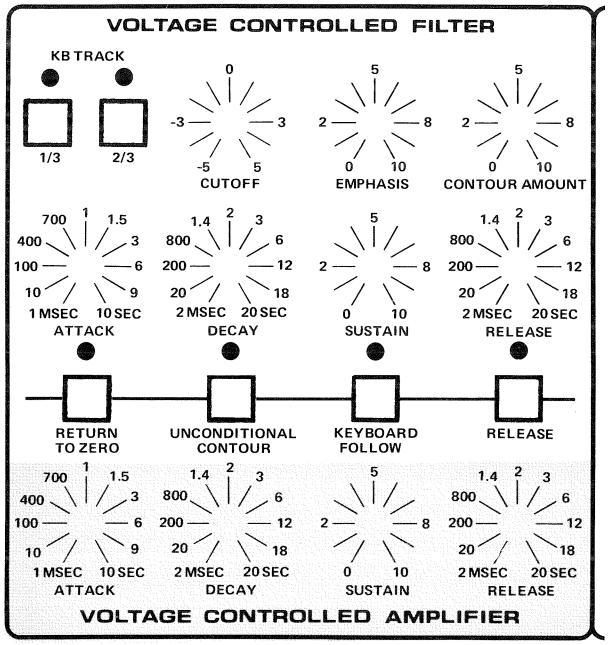
10.0 CONTOUR CONTROLS.
This set of four switches affects both Contour Generators.

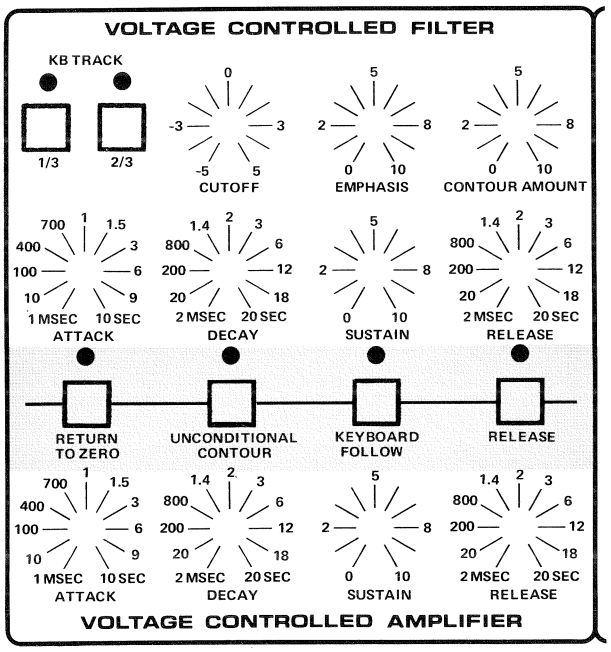
10.1 RETURN TO ZERO.
Normally, the Contour Generators, if retriggered during the attack segment, start from the existing voltage level. With this switch on, the attack segment will always reset to zero volts.

10.2 UNCONDITIONAL CONTOUR.
With this switch off, the Contour Generators will go into their release states (if the RELEASE SWITCH [10.4] is on or the RELEASE FOOTSWITCH [15.1] is depressed) only when you let up on a key. With the switch on, when you let up on a note, the Contour Generators will go through their entire attack phase and then jump immediately into the release state.

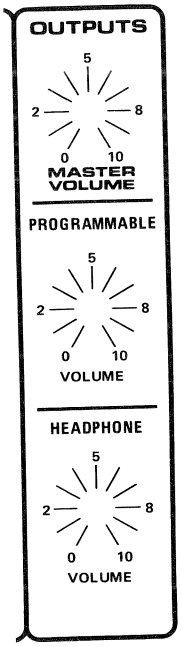
10.3 KEYBOARD FOLLOW.
When this switch is on, the voltage from the keyboard varies the attack, decay and release times of the Contour Generators. The lower you play, the longer the times; the higher you play, the shorter the times.

10.4 RELEASE.
Turns the release segment of the Contour Generators on and off. This control interacts with the RELEASE FOOTSWITCH (15.1).





11.0 OUTPUTS.



11.1 MASTER VOLUME.
A non-programmable volume control.

11.2 PROGRAMMABLE VOLUME.
Used for matching volume levels between programs.

11.3 HEADPHONE VOLUME.
A non-programmable volume control that's independent of the MASTER VOLUME control (11.1). It adjusts the level of the stereo headphone output.

THE BACK PANEL

12.0 HI-LEVEL AUDIO OUTPUT.

12.1 BALANCED.
A transformer-balanced 600 ohm output.

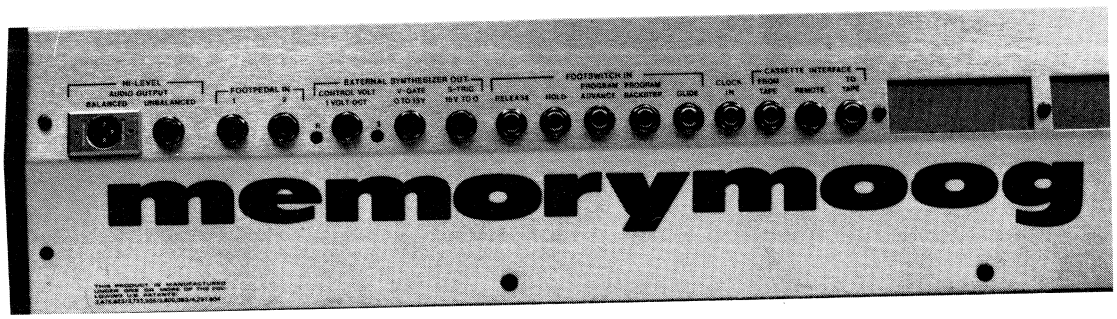
12.2 UNBALANCED.
An unbalanced low-impedance output.

13.0 FOOTPEDAL IN.

13.1
Input for a 5-volt voltage pedal controller whose function is programmed on the front panel (see 4.0).

13.2
Input for a 5-volt voltage pedal controller whose function is preprogrammed on the front panel (see 4.0).

Note that inputs 1 and 2 (13.1 and 13.2) are crosscoupled; if you have only one pedal in, that pedal's voltage will be applied to both front panel pedal sections.



BACK PANEL

14.0 EXTERNAL SYNTHESIZER OUT.

14.1 CONTROL VOLT 1 VOLT/OCT.
A 1 volt-per-octave (± 10%) output for controlling an external synthesizer or synthesizer accessory. Range and scale trimmers for tuning the output to an external synthesizer are accessible through the rear panel.

14.2 V-GATE 0 - 15V.
A voltage gate output with a level of from 0 to 15 volts for interfacing with instruments which accept voltage gates.

14.3 S-TRIG 15V TO 0.
A switch trigger output with a range of 15 volts to 0 volts. For interfacing to instruments with switch trigger inputs.

15.0 FOOTSWITCH IN.

15.1 RELEASE.
Accepts a switch input for turning the release portion of the Contour Generators on and off (see 10.4). With the RELEASE switch on the front panel on, depressing the RELEASE FOOTSWITCH will turn the RELEASE switch on the panel off. At that point, the RELEASE FOOTSWITCH will act as a SUSTAIN PEDAL would on a piano: pressed down, the RELEASE function of the CONTOUR GENERATORS (8.5 and 9.0) will be on; let up, the RELEASE function of the CONTOUR GENERATORS will be off.

15.2 HOLD.
A switch input for turning the HOLD function (1.8) on and off.

15.3 PROGRAM ADVANCE.
A switch input for advancing through the PROGRAM SEQUENCES (3.7).

15.4 PROGRAM BACKSTEP.
A switch for stepping through the PROGRAM SEQUENCES (3.7) in reverse order.

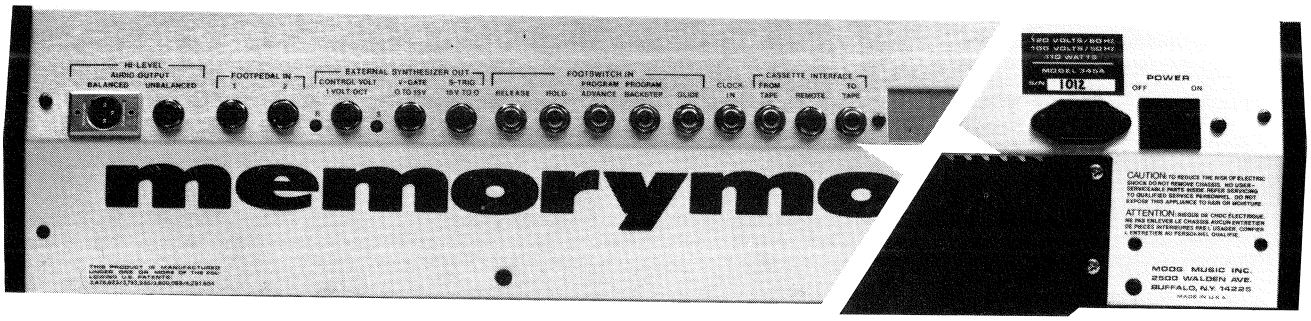
15.5 GLIDE.
Turns the front panel GLIDE switch on or off.

15.6 CLOCK IN.
Replaces the internal clock from the LFO (5.0) with an external clock.

16.0 CASSETTE INTERFACE.
Connections are made from the three jacks to a cassette recorder for transfer of memory contents to and from tape.

17.0 POWER ON/OFF.
Turns the Memorymoog on and off.

18.0 POWERCORD.
A detachable cord is supplied with your instrument. Be careful to grasp it by the plug when taking it out of an electrical outlet.



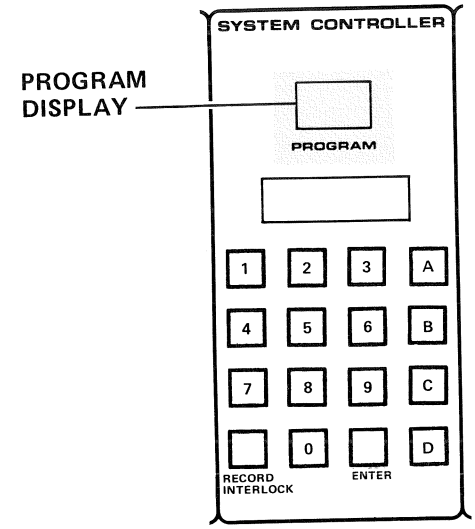
BACK PANEL

SECTION III

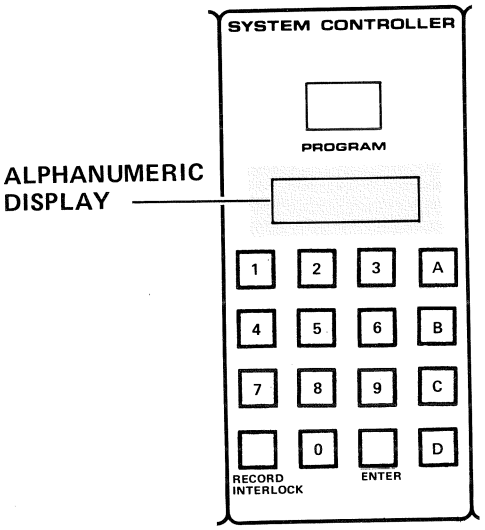
THE SYSTEM CONTROLLER

The SYSTEM CONTROLLER is the heart of the Memorymoog. Of all the front panel controls, you'll find yourself using the SYSTEM CONTROLLER most frequently. It is used to store and recall patches, set up keyboard modes, set up arpeggiation modes, control program sequencing, access the cassette interface, and many other present and future functions.

When you first power up the Memorymoog, you'll notice that the number 1 appears in the large LED display labeled PROGRAM. This tells you that program #1 is called up and ready to play. This window, the PROGRAM DISPLAY (3.1), will always show which program is currently called up and ready to play, or which program is about to be entered.



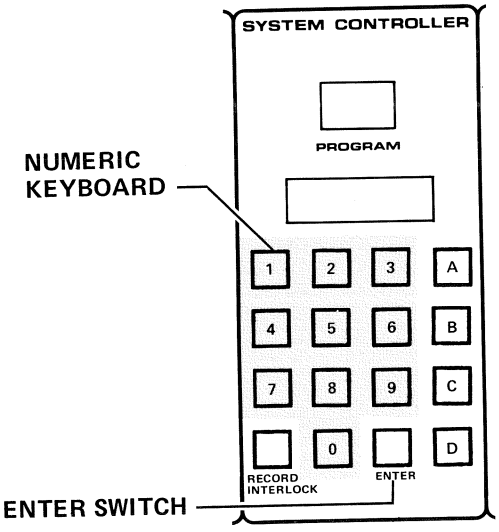
As discussed in the quick setup guide, let your instrument warm up for about 10 minutes, press the AUTO TUNE switch (1.1), and let the instrument tune itself before playing. After the AUTO TUNE routine is complete, program #1 will appear again in the PROGRAM DISPLAY and the appropriate LEDs for program #1 will light up. (Should you need to tune the instrument at any time after it's been warmed up, the computer will always remember the state of the panel controls just prior to the tuning routine and return to it.) The Alphanumeric Display (3.2) will read "6 TUNED" indicating that all six voice cards have been tuned successfully. If any number less than six appears you should hit AUTO TUNE again. If all six voice cards still fail to tune, try turning the instrument off for a moment. Then turn it on again and hit the AUTO TUNE switch. If all this fails, contact an authorized service center or call our factory service center for assistance.



CALLING UP PROGRAMS

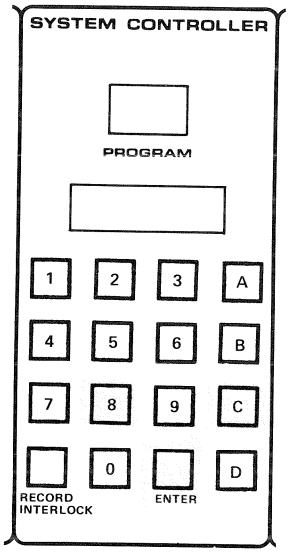
To call up a program, hit any desired number from 0 to 99 on the Numeric Keyboard (3.3) and follow it by pressing the ENTER switch.

The ENTER switch must be pressed in order for a new program to replace the one that is currently called up. The new number appears on the display immediately, but the new program is not active until the ENTER switch is pressed.



RECORDING PROGRAMS

In order to record your own patches into the program memory you have to ENABLE the record function. To do this, press PREFIX BUTTON C (3.6), hit 8, and hit ENTER. This will display the status of the instrument. The Alphanumeric Display will read "DISABLED" or "ENABLED." Now you must enter a four-digit security code (when each instrument is shipped, the code is 0000). If you enter the wrong code, the display reads "BAD CODE" and returns to normal operation. If you enter the correct code, the instrument shows the updated status (ENABLED or DISABLED) and returns to normal operation. To change the code, hit C, hit 8, hit ENTER, then hit C again; the instrument assumes you want to change the security code and displays "OLD CODE." You enter the existing code; if the code is incorrect the display reads "BAD CODE," and operation returns to normal. If the code is correct, the display reads "NEW CODE," and you enter any new four-digit code number, followed by ENTER. A convenient code number is the last four digits of your telephone number.

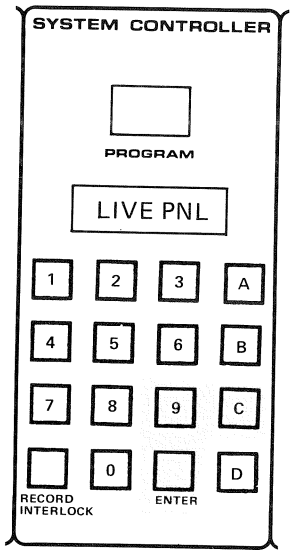


MEMORY ENABLE/DISABLE PROCEDURE

PRESS C
PRESS 8
PRESS ENTER = ENABLED OR DISABLED MEMORY RECORD FUNCTION

Once you've ENABLED the memory, you're ready to store patches. The memory position you decide on should be one that has a patch you don't want, since once you record another patch over it, it's gone (unless, of course, you've stored it on cassette tape using the procedure explained a little later).

There are two ways of arriving at a patch you like: setting one up from scratch (starting from a "live panel"), or editing (changing) a prerecorded patch. To set up a live panel — one where all the controls are active, overriding the memory values — hit PREFIX C, number 9, and ENTER.

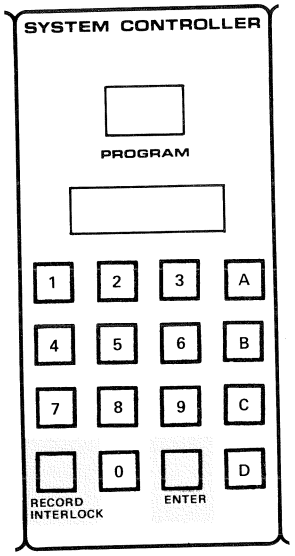


LIVE FRONT PANEL

HIT C
HIT 9
HIT ENTER = LIVE PANEL

To edit or change any preset program, change any of the parameters by moving a pot or pushing a switch. When you hit a switch, you'll notice the Alphanumeric Display will read "EDIT" to tell you you've changed a parameter of the program. If you turn a pot, you'll see six numbers appear in the Alphanumeric Display. The three on the left of the screen tell you what the control's value is in memory, and the three on the right tell you the current value of the control. Note that edit changes aren't permanent changes in the memory. Hitting the ENTER switch at any time while you're editing a sound will immediately restore the patch to its original preprogrammed state. To hear this effect, call up a familiar patch. Make a few edits — changing the CUTOFF of the FILTER, or change the octave settings of the oscillators. Now hit the ENTER switch again. Everything will jump back to the way it was before you edited the sound.

RECORDING A PATCH



HIT RECORD INTERLOCK AND HOLD IT
HIT ENTER = RECORD A PATCH (EITHER FROM A "LIVE PANEL" OR FROM HAVING EDITED A PREPROGRAMMED PATCH)

Suppose you want to record a new patch. What do you do? There are two ways to go about it:
1) Find the place you want to put it; punch that program number. Hit C, hit 9, hit ENTER to put the panel into a live state. Set up the patch the way you want it, then hit the RECORD INTERLOCK switch. This locks all the front panel controls so that moving them will have no effect at all on the patch as long as the RECORD INTERLOCK switch doesn't get hit again, cancelling the LOCK. Then while holding down the RECORD INTERLOCK switch, press the ENTER button. The Alphanumeric Display will read either "RECORDED" to indicate a successful recording, or "DISABLED" to indicate that the record function of the memory is off and must be turned on to record a patch in memory.

The other method of recording a patch involves recording edited versions of programs using the RECORD INTERLOCK switch to freeze them in temporary memory, so they can be moved to other locations or checked against the original patch. Edit a patch, hit the RECORD INTERLOCK switch to put the edited patch in temporary memory and freeze the front panel controls. Now if you hit the ENTER switch (*don't hold the* RECORD INTERLOCK *button down!*) you'll reinstate the original preset program. Hitting the RECORD INTERLOCK switch will bring back the edited version of the patch. This lets you do A/B comparisons between patches.

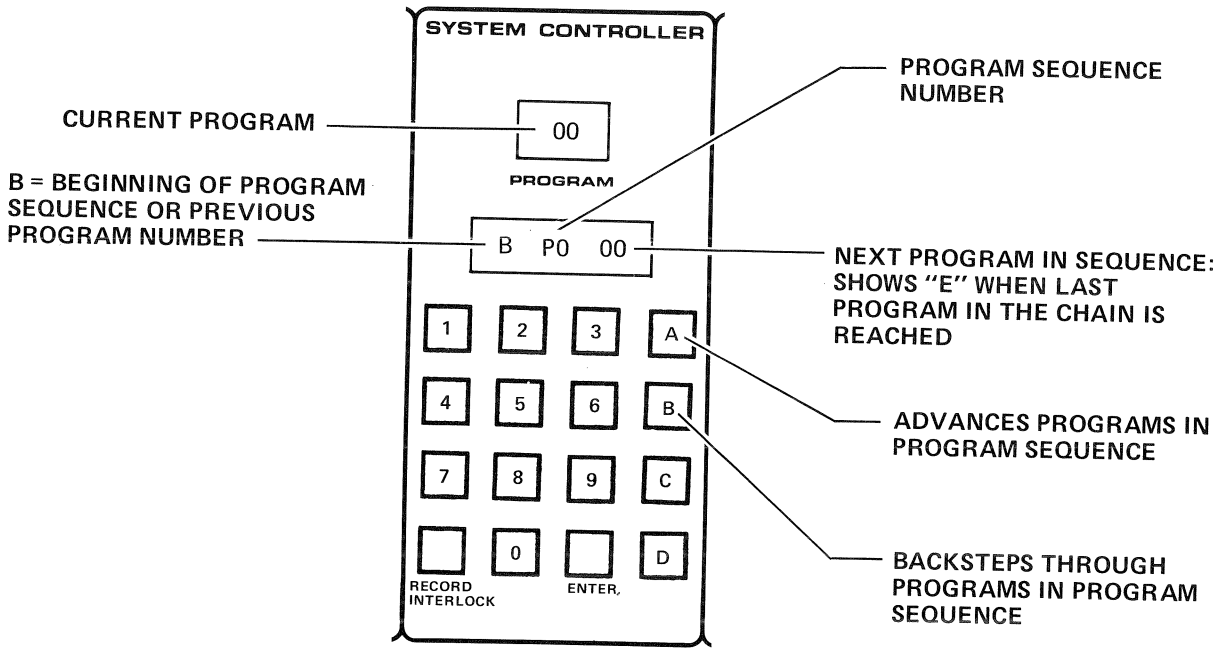
Note that you aren't limited to A/B comparisons between the edited patch and its original form. All you have to do is hit the RECORD INTERLOCK switch, putting the edited or live panel patch into temporary memory, and call up the program you want to check it against (hit a number followed by ENTER). To get the LOCKED setting back, hit the RECORD INTERLOCK switch again. If you decide you want to record the LOCKED setting into a memory position, hold the RECORD INTERLOCK switch down and hit the ENTER button. Be sure the PROGRAM DISPLAY is showing the desired program number; otherwise you'll erase a patch you may have wanted to save.

PROGRAM SEQUENCES

The D PREFIX switch is used to call up and record PROGRAM SEQUENCES. There are 10 PROGRAM SEQUENCES in the Memorymoog. These are chains of up to 20 programs which the user determines.

To call up a PROGRAM SEQUENCE hit D, the PROGRAM SEQUENCE number (any number from 0 to 9), and hit ENTER. What you will see in the PROGRAM DISPLAY is the first program in the PROGRAM SEQUENCE. The Alphanumeric Display will look like this:

PROGRAM SEQUENCE DISPLAY



There are two possible methods for stepping forward or backward through the programs in a PROGRAM SEQUENCE. You can use the A and B PREFIX switches on the Numeric Keyboard (see diagram above) or you can use ADVANCE and BACKSTEP footswitches (not supplied with the instrument, but available as Moog accessory number 1122).

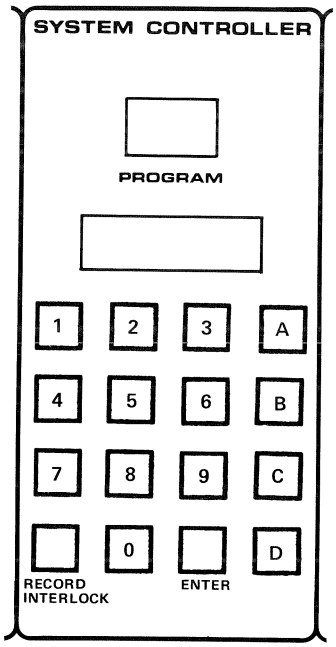
The A PREFIX switch advances (steps forward into) the PROGRAM SEQUENCE, while the B PREFIX switch backsteps through the PROGRAM SEQUENCE.

LOADING YOUR OWN PROGRAM SEQUENCE

This process is fairly simple, but may require some practice until you get the hang of it. The procedure is as follows:

Hit D to get yourself into the PROGRAM SEQUENCE MODE. Then **hit D again,** putting you into LOAD MODE (an L will appear in the Alphanumeric Display). **Hit a number from 0 to 9** for the number of the PROGRAM SEQUENCE you wish to load, and then hit ENTER.

To load in the first program in the PROGRAM SEQUENCE, hit the number of the program, hit ENTER, and hit A. This will load the first program into the PROGRAM SEQUENCE. Repeat until you've either filled up the PROGRAM SEQUENCE (20 programs maximum for each SEQUENCE), or until you've got all the programs you desire to the maximum number of 20. (Putting less than 20 programs in a chain is possible.)



HIT D
HIT D
HIT A NUMBER FROM 0 TO 9
HIT ENTER = LOADING MODE

HIT #
HIT ENTER
HIT A
HIT ENTER = LOAD A PROGRAM FORWARD INTO PROGRAM SEQUENCE

HIT #
HIT ENTER
HIT B
HIT ENTER = LOAD A PROGRAM BACKWARD INTO PROGRAM SEQUENCE

Should you decide that you want to replace a program in the SEQUENCE, you can step through the chain to the program you want to replace and repeat the steps above for recording a program into the SEQUENCE. This will update the PROGRAM SEQUENCE.

Using the B PREFIX switch in place of the A PREFIX switch in the above loading procedure will cause the programs to be loaded into the previous position rather than in the position shown.

Here's a hypothetical PROGRAM SEQUENCE and the procedure for loading it for you to practice on:

The SEQUENCE we want runs programs 10, 20, 30, 40, 50, 60, 70.

To load it proceed thus:

1) Hit D
2) Hit D again
3) Hit 0 = load PROGRAM SEQUENCE 0.

4) Hit 10
5) Hit ENTER
6) Hit A = load first program into first position of SEQUENCE 0.

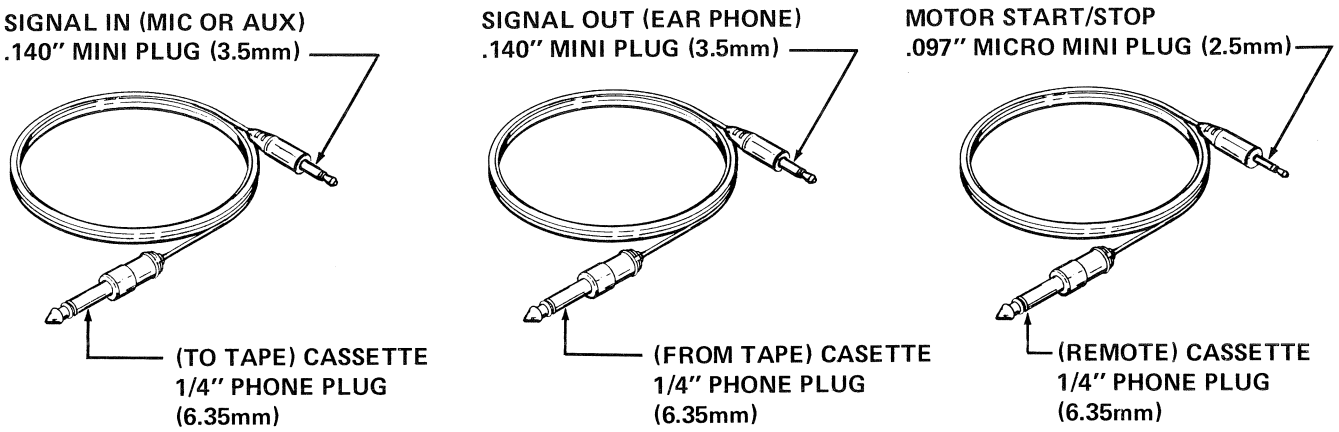
7) Hit 20
8) Hit ENTER
9) Hit A = load second program into second position of SEQUENCE 0.

CONTINUE until you've loaded all the programs into the SEQUENCE. To stop loading PROGRAM SEQUENCE 0, hit D again. This will get you out of PROGRAM SEQUENCE MODE. Hitting D, 0, ENTER will recall PROGRAM SEQUENCE 0. Step through it to see if it's correct. The SEQUENCE should run 10, 20, 30, 40, 50, 60, 70. If it doesn't, try to correct your mistake. Correcting mistakes is a great way to familiarize yourself with the operation of the PROGRAM SEQUENCE MODE.

Note that if you should need to run more than 20 programs in a PROGRAM SEQUENCE, the PROGRAM SEQUENCE automatically jumps to the next PROGRAM SEQUENCE number when it has reached the end of a SEQUENCE. Step through to the end of PROGRAM SEQUENCE 0 (an E will appear in the right side of the Alphanumeric Display) and keep going. It will run to PROGRAM SEQUENCE 1. If you step through PROGRAM SEQUENCE 0 backwards (using either the B PREFIX switch or the BACKSTEP footswitch) it will jump to PROGRAM SEQUENCE 9.

THE CASSETTE INTERFACE

This is used to store information from the memory onto cassette tapes, expanding your library of patches beyond the 100 that the Memorymoog will hold. To access the interface, it's necessary to connect the cassette properly.



Connect the Memorymoog TO TAPE output to the MIC level input of the recorder. (Use only one channel of a stereo recorder.) Connect the Memorymoog FROM TAPE input to the EARPHONE (or line level) output of the recorder and, where applicable, connect the Memorymoog REMOTE jack to the REMOTE or START/STOP input of the recorder. If your recorder is not so equipped, start/stop must be done manually.

If you don't have a small cassette tape recorder with automatic level control, there is a leader signal at the front of the cassette save function which you can use to set the level of your recorder. It should be set at around ± 3 on the VU meter to ensure sufficient level.

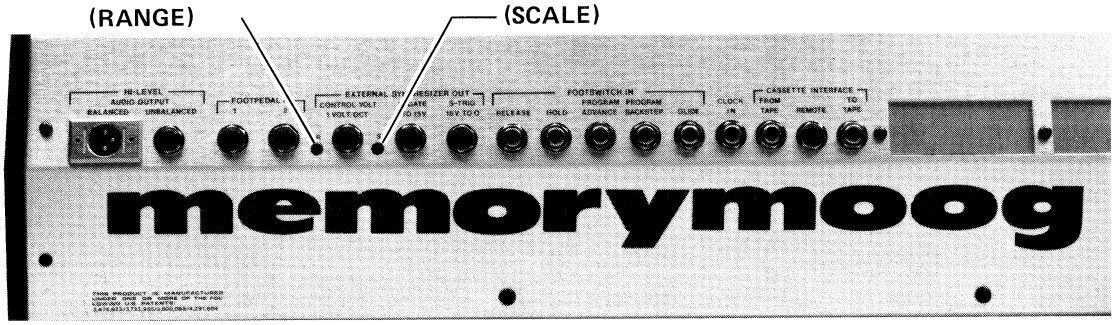
To save programs onto tape, hit PREFIX C, press 1, press ENTER. This starts the cassette save operation, which takes about 30 seconds. When saving to tape, your instrument is inoperative. When it's complete, the Alphanumeric Display will read "SAVED."

To verify that saving took place correctly, rewind the tape and press PREFIX C, hit 3, hit ENTER, and start the tape. When the tape has been completed, the Alphanumeric Display will read "VERIFIED" if the tape has been made properly. It will read "ERROR" if there's a problem. If the playback volume is too low, the Display will read "VOL LOW."

To load programs from a cassette tape, press PREFIX C, hit 2, hit ENTER. When the tape has been completed, the Alphanumeric Display will read "LOADED" if there wasn't any problem. It will read "VOL LOW" if the playback volume is too low, and it will read "ERROR" if there's some other problem. Generally speaking, you should always verify a tape before you try to load it.

INTERFACING THE MEMORYMOOG TO A MONOPHONIC SYNTH

It's possible to control an external monophonic synthesizer using the INTERFACE jacks (14.0) provided on the Memorymoog's back panel.



BACK PANEL

The CONTROL VOLT 1 VOLT/OCT jack is used to supply control voltage out from the Memorymoog to the external synthesizer. The other two jacks — V-GATE 0 TO 15V and S-TRIG 15V TO 0 — are used to supply either voltage or switch triggers from the Memorymoog to the external synthesizer, depending on which type of trigger signal it requires. Consult the owner's manual for the synthesizer you intend to interface to for details of the trigger signal required.

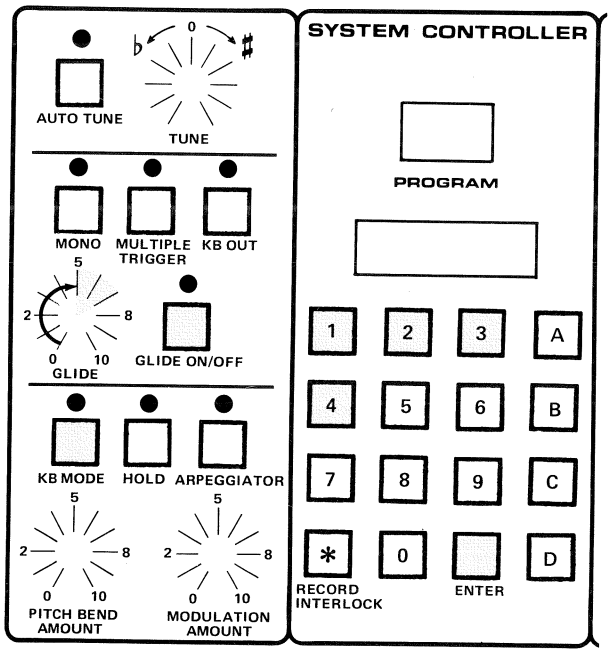
Once you've connected the necessary patch cords between instruments, it may be necessary to retune the Memorymoog output to the external synthesizer, especially if that synthesizer has a keyboard that ends in notes other than C. To do this, use the RANGE (R) and SCALE (S) trimpots on the back panel of the Memorymoog. The RANGE control lets you tune the Memorymoog output ± an octave. Hit the lowest C on the Memorymoog, and tune it to the lowest C on the instrument you're interfacing to. The SCALE trimpot is used to tune the outer range of the Memorymoog output to the outer range of the instrument you're interfaced with. Hit the highest note on the Memorymoog and adjust the SCALE trimmer until it's in tune with the external synth. You may have to go back and forth between the RANGE and SCALE controls a bit before the instruments are exactly in tune with each other.

The KB OUT switch (1.5) on the front panel is used to disconnect the external synthesizer from the Memorymoog without unplugging all the patch cords. Its function is programmable.

THE KEYBOARD

The keyboard is the source of control voltages that are applied to the oscillators, telling them what pitches to produce. The lower the note you play, the lower the corresponding voltage the keyboard will put out. It functions in two basic modes: POLYPHONIC and MONOPHONIC.

In its four POLYPHONIC MODES you can play up to six notes simultaneously. The keyboard puts out a separate control voltage for each voice card. There are four different ways that the computer assigns voices to the notes you play when you're in a POLYPHONIC mode. The effects of the different keyboard modes will not be apparent unless glide and/or long release times are turned on. To hear the various keyboard modes, use a fairly straight preset, a brassy one or something similar. Turn the GLIDE (1.6) on and set it at 5 or more. To set the mode of the keyboard, hit the KB MODE switch (1.7). The Alphanumeric Display (3.2) will then show "POLYPHONIC 1, 2, 3, or 4" depending on the keyboard mode programmed. Hit 1 on the Numeric Keyboard (3.3) followed by ENTER. This puts you in KEYBOARD MODE 1, which is called CYCLIC indicating that the voices will jump around to new notes every time one is played. Hitting a widely spread chord on the keyboard more than once, letting the glide finish its cycle, will let you hear that no matter how many times you strike the chord, each voice has glide on it.



POLYPHONIC KEYBOARD MODES

HIT KB MODE
HIT 1
HIT ENTER = KB MODE # 1

HIT KB MODE
HIT 2
HIT ENTER = KB MODE # 2

HIT KB MODE
HIT 3
HIT ENTER = KB MODE # 3

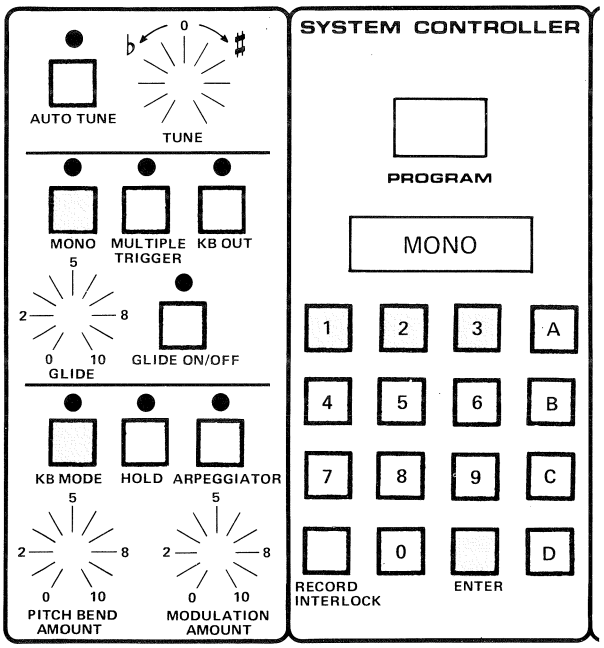
HIT KB MODE
HIT 4
HIT ENTER = KB MODE # 4

Next, hit KB MODE, hit 2, hit ENTER. That will put the keyboard in POLYPHONIC MODE 2, CYCLIC WITH MEMORY. Now when you repeat the same chord over and over again, you should only hear glide the first time you strike the chord. The second and each consecutive time you strike that chord, the computer memory remembers that the voices have been assigned to the various pitches you are playing. It won't reassign them until you hit a new note or set of notes.

Hit KB MODE, hit 3, hit ENTER. This gets you to KEYBOARD MODE 3, RESET TO VOICE A. Every time you let up on all the notes on the keyboard, the next note you hit will be assigned to VOICE A. Playing a single line will produce a sound similar to playing the same line on a monophonic synthesizer.

Hit KB MODE, hit 4, hit ENTER to hear KEYBOARD MODE 4, RESET TO VOICE A WITH MEMORY. The effect is just like that of CYCLIC WITH MEMORY in that when you strike the chord repeatedly, you only hear glide the first time you hit the chord. From then on the instrument remembers that the voices have been assigned specific notes and it won't reassign them until you strike new notes. This mode differs from CYCLIC WITH MEMORY in that the first note played after no notes have been held down is assigned to VOICE A.

In MONOPHONIC MODE, the keyboard will only let you play one note at a time. There are three different MONOPHONIC PRIORITY modes that determine what note sounds should you play more than one note at a time when in MONO MODE. To get to the MONOPHONIC KEYBOARD MODES, turn the MONO switch (1.3) on. Then hit the KB MODE switch (1.7), and press either 1, 2, or 3, followed by ENTER. KEYBOARD MODE 1 is last note priority — the last note played will sound over all others no matter how many notes you hold down. KEYBOARD MODE 2 is low-note priority — the lowest note played gets priority. KEYBOARD MODE 3 is high-note priority — the highest note will sound if more than one note is played. All three modes have interesting uses, especially when used in conjunction with the SINGLE/MULTIPLE TRIGGER switch (1.4) and/or when the Memorymoog is interfaced with a monophonic synthesizer.



MONOPHONIC KEYBOARD MODES

HIT KB MODE
HIT 1
HIT ENTER = KB MODE # 1

HIT KB MODE
HIT 2
HIT ENTER = KB MODE # 2

HIT KB MODE
HIT 3
HIT ENTER = KB MODE # 3

CHANGING THE NUMBER OF VOICES THE KEYBOARD CONTROLS IN MONO MODE

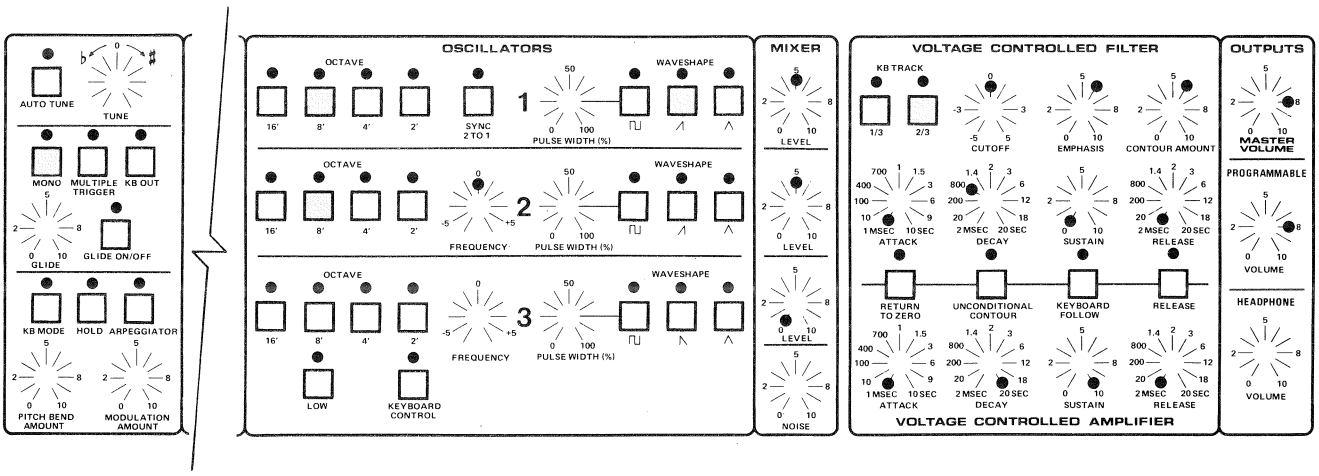
When you put the keyboard into its MONOPHONIC MODE by pressing the MONO switch (1.3), the keyboard will play only one note at a time. It will control from 1 to 18 oscillators, depending on how many voice cards are being controlled. You can program the number of voice cards controlled by turning the MONO switch (1.3) on, hitting the KB MODE switch (1.7), pressing ENTER, and then hitting a number from 1 to 6 on the Numeric Keyboard (3.3), and pressing ENTER again. If you hit a 1, you will control three oscillators as a Minimoog does. If you want to hear the sound of only one oscillator, turn the volume controls in the MIXER (7.0) of two of the oscillators to 0. The more oscillators you control, the thicker and fatter the sound will be. Controlling all 18 oscillators in unison creates a very massive sound.

SINGLE/MULTIPLE TRIGGER

When the SINGLE/MULTIPLE TRIGGER switch (1.4) is off, the keyboard waits until all keys are released before a new key depression will put out a new trigger signal, which is used to start the CONTOUR GENERATORS (8.5 and 9.0). This state is called SINGLE TRIGGERING, and it's useful for playing legato passages in MONO MODE.

You can emphasize phrases in SINGLE TRIGGER MODE by deliberately attacking only the first note in a phrase, playing the rest of it with a legato touch. This produces only one trigger for the entire phrase, emphasizing the first note, letting the others be played with what remains of the single CONTOUR. If you've never played a single-trigger monophonic synthesizer before, it may take some practice to get used to the technique. With this patch try playing a familiar run or scale, producing new triggers only at the first note. Do it slowly to begin with and increase the speed as you start to master the technique. Also, try the different KEYBOARD MODES while you practice and notice the differences in priority between high-note, low-note, and last-note modes.

SINGLE/MULTIPLE TRIGGER



With the SINGLE/MULTIPLE TRIGGER switch (1.4) on, the keyboard will put out a new trigger for every note played, regardless of whether or not any other note is still being held down. You'll notice that if you try to play legato, the keyboard will still put out new triggers, foiling your every attempt to avoid them. MULTIPLE TRIGGERING is great for playing those pyrotechnic runs where you want every note to stand out. It covers up for any note you hit sloppily, whereas with SINGLE TRIGGERING, you have to be sure to hit every note distinctly in order for it to be articulated clearly.

THE HOLD FUNCTION

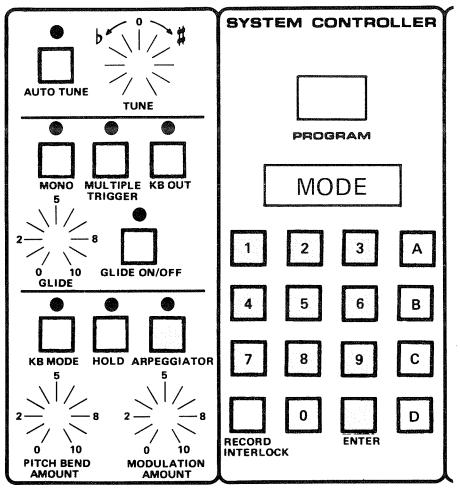
The HOLD switch (1.8) is used for building chords that you can subsequently control in parallel motion from the keyboard. Play a chord. Continue holding it while you press the HOLD button. Let up on the chord and then play a single note. You should hear the chord and be able to transpose it up and down by playing the keyboard. If you want to build chords that are too wide to simultaneously play while pressing the HOLD switch, push the HOLD switch, continue holding it and play the chord you want, one note at a time. When the HOLD switch is released, the chord pattern is stored. Since the HOLD function is *not* programmable, you can switch to other programs while retaining the "held" chord.

THE ARPEGGIATOR

Turning the ARPEGGIATOR switch (1.9) on puts the keyboard immediately into a MONOPHONIC ARPEGGIATION MODE. However, if the instrument is in MONOPHONIC MODE already, no arpeggiation will occur. You'll hear the highest, lowest, or last note you've hit retrigger depending on the MONO KEYBOARD MODE you're in. The rate of the arpeggiation is set by the LFO RATE knob (5.0).

When you first turn on the arpeggiator, the Alphanumeric Display will read "MODE (1 - 9)" (the arpeggiator modes are listed below). To change the ARPEGGIATION MODES, hit the desired MODE NUMBER followed by ENTER immediately after you turn on the ARPEGGIATOR.

ARPEGGIATION MODES



TURN ARPEGGIATOR ON
HIT 1
HIT ENTER = MODE 1, UP

HIT 2
HIT ENTER = MODE 2, DOWN

HIT 3
HIT ENTER = MODE 3, UP-DOWN

HIT 4
HIT ENTER = MODE 4, UP (LATCHED)

HIT 5
HIT ENTER = MODE 5, DOWN (LATCHED)

HIT 6
HIT ENTER = MODE 6, UP-DOWN (LATCHED)

HIT 7
HIT ENTER = MODE 7, AUTO TRIGGER (ALL VOICES TRIGGERED SIMULTANEOUSLY)

HIT 8
HIT ENTER = MODE 8, FIRST-TO-LAST

HIT 9
HIT ENTER = MODE 9, FIRST-TO-LAST (LATCHED)

THE OSCILLATORS

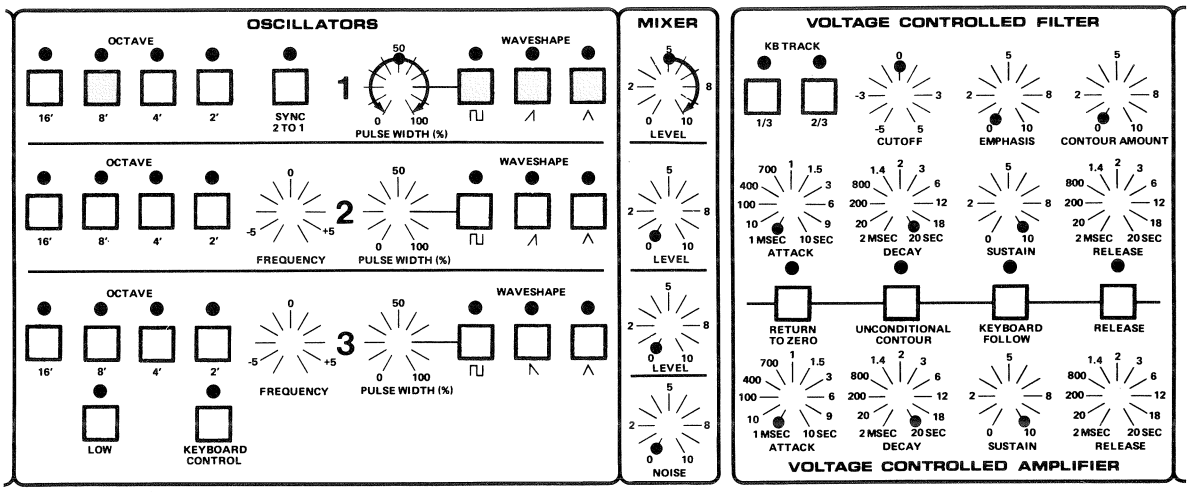
The 18 voltage-controlled oscillators of the Memorymoog produce the pitches you hear when you play the keyboard. The control voltage output from the keyboard determines the oscillators' pitch. Pitch is supplied by an oscillator when its waveform, a periodic fluctuation of voltage, is translated by a speaker cone into a fluctuation of air, which we perceive as pitch. There are a number of things which can alter the speed or frequency of the oscillators: incoming control voltages supplied by the keyboard, the FREQUENCY controls on the oscillators themselves (6.5 and 6.6), voltage from the two PROGRAMMABLE FOOTPEDALS (4.0), the PITCH BEND WHEEL (2.2), the LFO (5.0), the filter's CONTOUR GENERATOR (8.5), and the output of OSCILLATOR 3 when it's used as a modulation source in the VOICE MODULATION section (5.4).

As we explained in the introduction, each voice card holds three oscillators. There are six voice cards for a total of 18 oscillators. Each of the oscillator panel controls for OSCILLATORS 1, 2, and 3 actually governs six oscillators. To avoid confusion when we refer to OSCILLATOR 1, OSCILLATOR 2, and OSCILLATOR 3, we'll mean the set of six oscillators governed by each of those groups of controls.

WAVESHAPE

Each oscillator generates three waveshapes: pulse , sawtooth , and triangle . Each waveshape is a representation of fluctuations of voltage. These fluctuations produce different sets of harmonics, thereby creating a different timbre of tone color. If you want to listen to how they differ, set up this patch (start by pressing C, 9, ENTER on the NUMERIC KEYBOARD [3.3] to get a live panel):

TO HEAR THE DIFFERENT WAVESHAPES . . .

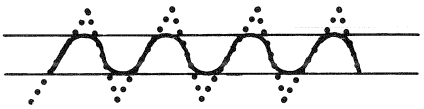


HOLD DOWN A NOTE IN THE CENTER OF THE KEYBOARD. TURN ON EACH WAVESHAPE SWITCH INDIVIDUALLY AND LISTEN TO THE EFFECT IT HAS ON THE TONE COLOR. TURN THE PULSE WIDTH CONTROL WHEN YOU GET TO THE PULSE WAVE AND NOTICE HOW CHANGING THE WIDTH OF THE PULSE WAVE AFFECTS ITS TONE.

Play a note on the middle of the keyboard and turn on the WAVESHAPE switches (6.4), one at a time. You'll notice that the triangle waveshape is soft and flute-like. That's because it has a simple harmonic content. The sawtooth wave is bright because it has all harmonics. It's good for producing brass- and string-like sounds. The pulse wave has a variable width. When you listen to it, move the PULSE WIDTH control (6.3) across its full range. You'll notice that at 0% the width gets so thin that the waveshape becomes inaudible. You can use this effect to advantage when you apply modulation from either the LFO (5.0) or the VOICE MODULATION section (5.4) to the pulse width of any of the oscillators, causing the oscillator to fade in and out. The pulse wave can sound anywhere from hollow to thin and nasal depending on how its width is set. It's useful for pipe organ sounds, strings, reeds, and so on.

You've probably noticed that you can mix the different waveshapes by turning the switches on simultaneously. This produces more complex waveshapes. Different waveshapes can also be produced by turning the MIXER level controls (7.0) up past 5. This causes clipping distortion. It can turn the triangle waveshape into a sine wave, which has no harmonics at all and is very flutey sounding.

NORMAL TRIANGLE WAVESHAPE

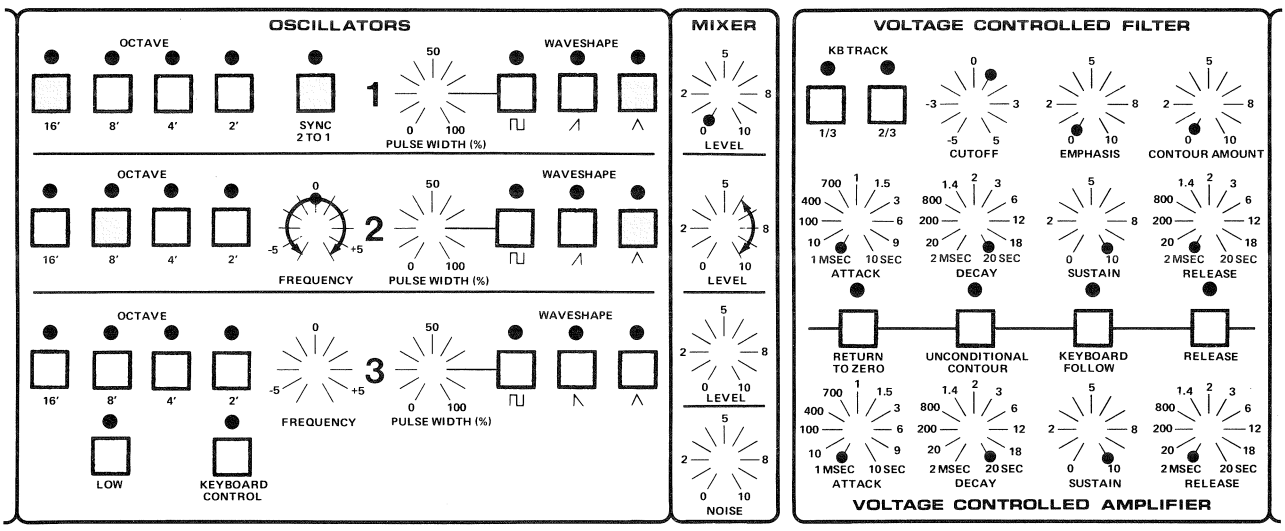


"CLIPPED" TRIANGLE/SINE WAVESHAPE

SYNC 2 TO 1

SYNC is short for synchronize. When the SYNC switch (6.2) is on, the fundamental frequency of OSCILLATOR 2 is locked to the fundamental frequency of OSCILLATOR 1. To hear the effect, start with the same live panel patch we used to hear waveshapes, but turn on the SYNC switch and turn up the volume of OSCILLATOR 2 and turn down the volume of OSCILLATOR 1 using the MIXER controls (7.0).

HEARING SYNC



TURN THE FREQUENCY CONTROL TO OSCILLATOR 2 ACROSS ITS FULL RANGE TO HEAR THE EFFECT OF SYNCING OSC 2 TO OSC 1.

TRY CHANGING THE OCTAVE SETTINGS OF OSCILLATOR 2. YOU'LL NOTICE THAT THE MORE REMOVED THE OCTAVE IS FROM OSCILLATOR 1, THE MORE PRONOUNCED THE SYNC EFFECT.

Hold a note in the middle of the keyboard and turn the outer ring of the FREQUENCY controls (6.5) for OSCILLATOR 2. Experiment with changing the octave settings of both OSCILLATOR 1 and OSCILLATOR 2. Remember that in this patch, you're only listening to the output of OSCILLATOR 2. By turning up the MIXER level controls to OSCILLATOR 1, you'll hear its output in addition to that of OSCILLATOR 2.

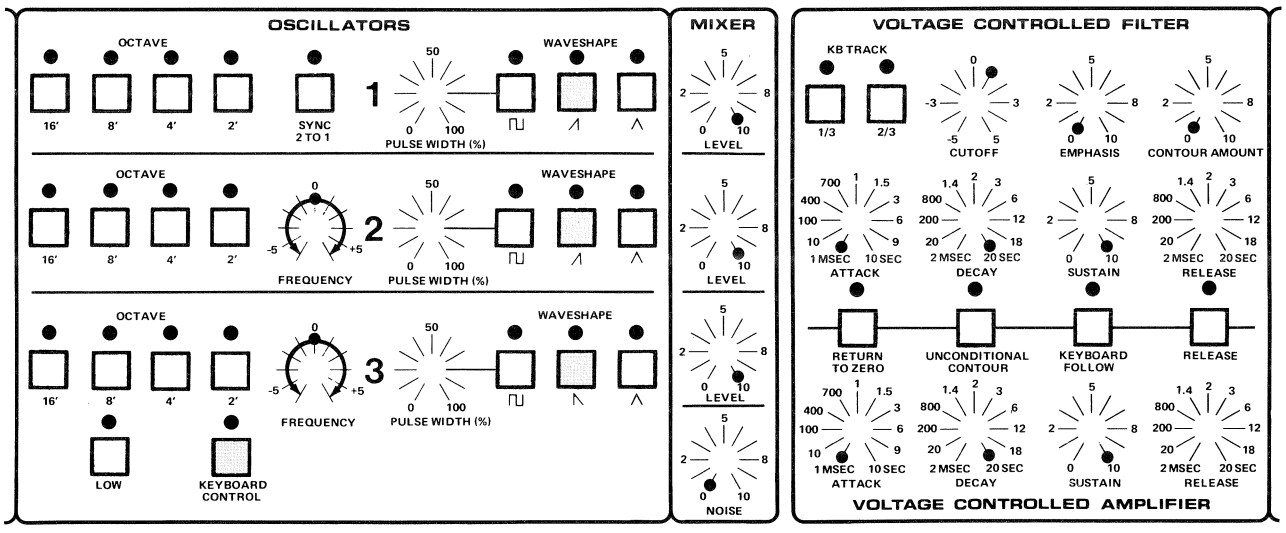
Interesting things start happening when you apply control voltages from a VOLTAGE PEDAL (4.0), the LFO (5.0), and/or the VOICE MODULATION section (5.4) to the frequency of OSCILLATOR 2 when it's synced to OSCILLATOR 1.

FREQUENCY CONTROLS

OSCILLATOR 2 and OSCILLATOR 3 both have controls (6.5 and 6.6) that let you detune them ± a minor sixth from OSCILLATOR 1. These FREQUENCY controls are set up concentrically: the outer ring is used for large tuning adjustments and the inner ring is for fine tuning adjustments. With these tuning controls you can do things like play triads from each single note on the keyboard, tuning OSCILLATOR 2 and OSCILLATOR 3 to a third and a fifth above OSCILLATOR 1. You can achieve compound intervals like ninths, tenths, and thirteenths by raising the octave setting of the OSCILLATOR after you've tuned it up to a second, third, or sixth using the OCTAVE switches (6.1).

To hear the effects of the FREQUENCY controls, go back to the live panel patch we've been working with and turn up the levels of OSCILLATORS 1 and 3 and turn off the SYNC switch. Then experiment with tuning the different oscillators to various intervals. Change the octave settings too.

THE FREQUENCY CONTROLS



EXPERIMENT WITH DIFFERENT OCTAVE SETTINGS AND DIFFERENT WAVESHAPE SETTINGS.

NOTICE THAT WHEN THE OUTER RING OF THE FREQUENCY CONTROLS IS TURNED, THE INNER RING SPINS AROUND, DUE TO THE FACT THAT THE INNER RING IS A FINE TUNE CONTROL.

OSCILLATOR 3 AS A LOW-FREQUENCY OSCILLATOR

OSCILLATOR 3 differs from the other two oscillators in that it can act as a source of modulation in the VOICE MODULATION section (5.4). For this reason it's useful to be able to use OSCILLATOR 3 as a LOW-FREQUENCY OSCILLATOR (LFO). The LOW switch (6.7) converts the oscillator from an audio range oscillator to a low-frequency oscillator.

When the LOW switch is turned on, the range of the oscillator drops by about five octaves. If you leave the MIXER level control for OSCILLATOR 3 up, you'll probably hear clicks. That's because the frequency of the oscillator is too low to be perceived as pitch. (For more on the application of OSCILLATOR 3 as an LFO, see the section on VOICE MODULATION.)

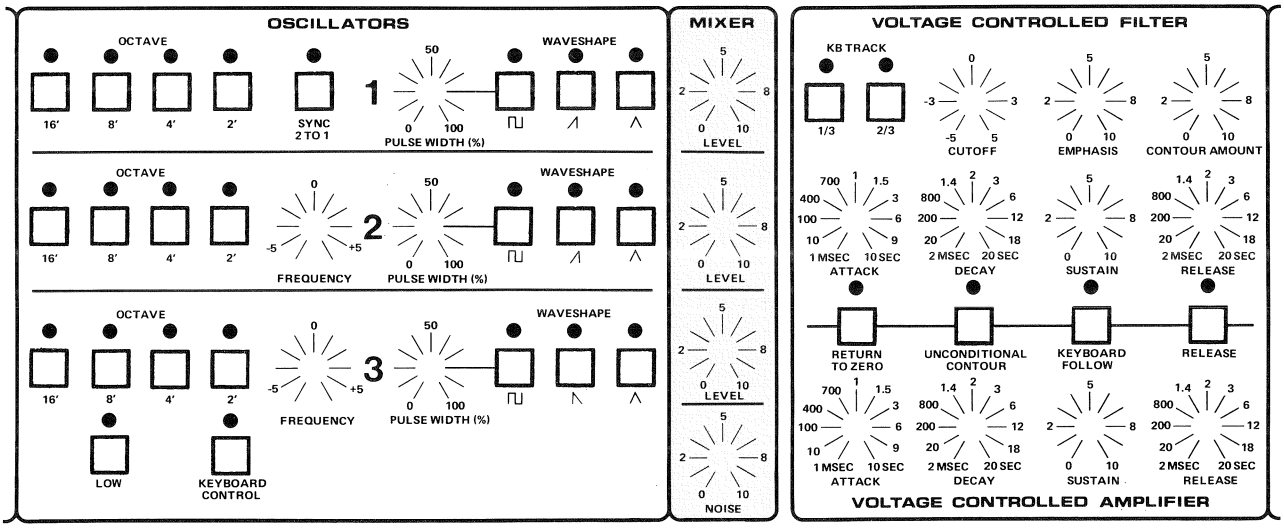
Turning the KEYBOARD CONTROL switch (6.8) off turns OSCILLATOR 3 into a drone oscillator. Without any control voltage from the keyboard to vary its pitch, the oscillator will remain at one constant pitch (unless you modulate it with some other voltage source like the LFO). With the KEYBOARD CONTROL switch on, OSCILLATOR 3 will be controlled by the keyboard like OSCILLATORS 1 and 2.

THE NOISE SOURCE

In addition to the three audio oscillators, there are two other sound sources in the Memorymoog, one of which is the NOISE SOURCE, whose level control is in the MIXER (7.0). The noise produced is *pink noise*, noise weighted to produce an equal amount of energy in each octave of the frequency spectrum. It has a deep sound and is useful for creating wind and surf effects. The other sound source is the VOLTAGE-CONTROLLED FILTER which is discussed later.

THE MIXER

The MIXER (7.0) is fairly straightforward. Each oscillator and the NOISE SOURCE has its corresponding level control that adjusts the volume of its output signal as it is fed into the FILTER. What may not be so obvious is that starting at about 4 or 5 on each MIXER control, clipping distortion is introduced. This effect enhances sounds by making them sound audibly larger than life. For a diagram of the effects of clipping distortion, see the section above on the oscillators.

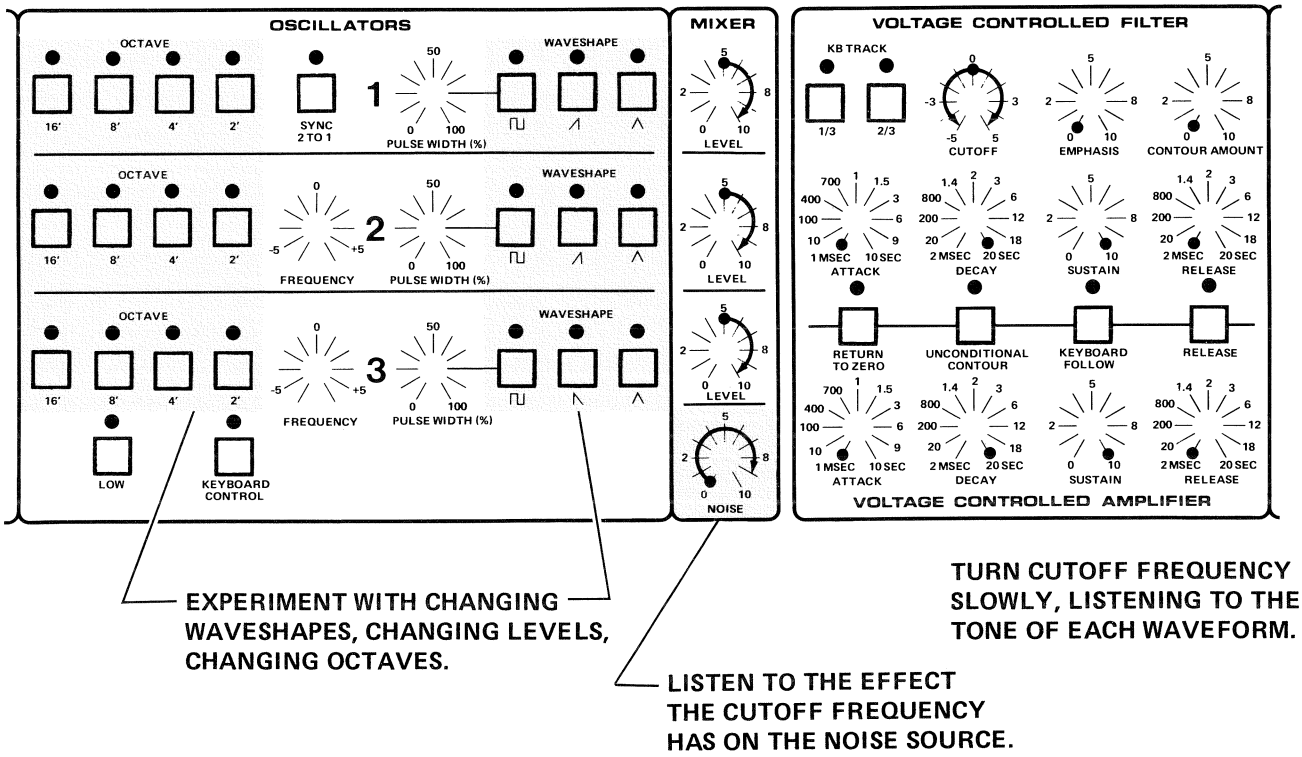


THE VOLTAGE-CONTROLLED FILTER

The job of the FILTER is to modify the signals from the sound sources (the OSCILLATORS and the NOISE SOURCE). The FILTER in the Memorymoog is the patented Moog 24dB/octave lowpass filter. It's called a lowpass filter because it filters out — stops — high frequencies from getting through and lets low frequencies pass. The setting of the CUTOFF control (8.2) determines how many high frequencies are filtered out and how many low frequencies are let through. All of the modulation voltage sources that can be applied to the filter affect its CUTOFF frequency.

To listen to the effect that changing the CUTOFF frequency has on the timber of the various waveshapes, set up this patch starting with a live panel:

HEARING WHAT CHANGING THE CUTOFF FREQUENCY DOES

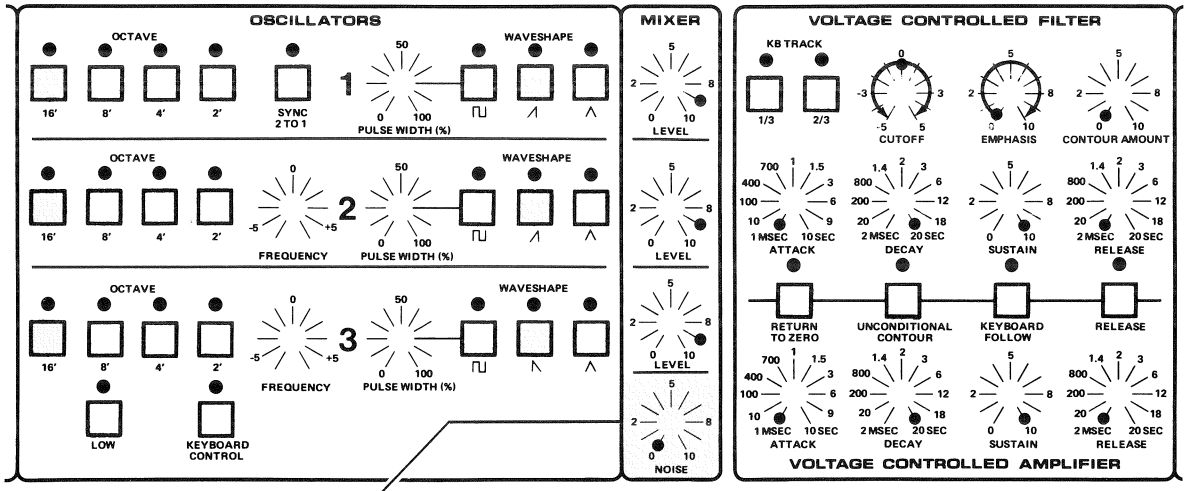


Play a low note on the keyboard. Slowly turn the CUTOFF control, listening to the harmonics being swept. You'll notice that if you play high notes and turn the CUTOFF control down too far (counterclockwise to -3 or - 5) you won't hear any sound at all. That's because the FILTER CUTOFF is below the frequencies of the note you're playing.

EMPHASIS

Turning this control up puts a *resonant peak* at the FILTER's CUTOFF frequency. When the setting is a little past 7, the FILTER actually starts oscillating on its own, becoming another sound source. Listen to the effect of turning the EMPHASIS control (see diagram on the following page):

EMPHASIS



SEE WHAT EFFECT THE EMPHASIS HAS ON THE NOISE SOURCE.

HOLD A LOW NOTE ON THE KEYBOARD. TURN THE EMPHASIS CONTROL UP SLOWLY. WHEN IT'S UP PAST 5, TRY ROTATING THE CUTOFF FREQUENCY CONTROL.

Notice that changing the CUTOFF control (8.2) moves the resonant peak so that it sweeps through the harmonics of the incoming waveform.

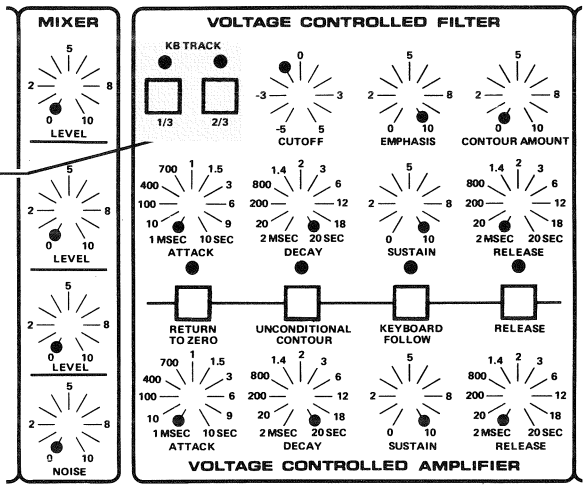
KB TRACK

The two KB TRACK switches (8.1) route control voltage from the keyboard to the CUTOFF frequency of the FILTER. The control voltage is added by thirds. Turning both switches on applies maximum keyboard control voltage to the CUTOFF. The keyboard control voltage is always proportionate to the location of the note you're playing on the keyboard: i.e., a low note puts out less control voltage than a high note. Experiment with adding different amounts of keyboard voltage to the filter, first using no EMPHASIS. Notice that when you turn the CUTOFF knob up beyond 0, the keyboard voltage appears to have little or no effect. That's because it is effectively opening the FILTER all the way up; there's no way the CUTOFF can open any farther for it to have any more audible effect.

An interesting thing happens when you apply the keyboard voltage in the various amounts to the filter if you have the EMPHASIS turned up past 7 — so the FILTER is oscillating. You can play the FILTER as if it were another oscillator. To try this, put the EMPHASIS up to 10, the CUTOFF on 0, and turn all the MIXER level controls (7.0) down to 0. That way, you'll only be listening to the FILTER.

PLAYING THE FILTER

VARY THE AMOUNT OF KEYBOARD IN WITH THESE SWITCHES.



PLAY A SCALE ON THE KEYBOARD TO HEAR HOW CHANGING THE KEYBOARD CONTROL VOLTAGE ALTERS THE INTONATION.

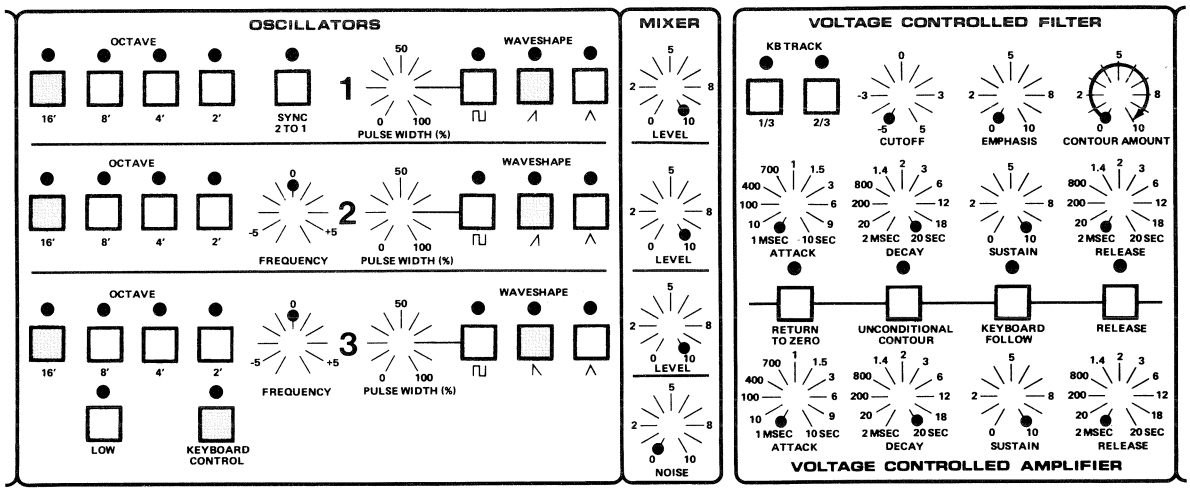
Playing a scale on the keyboard with different amounts of keyboard voltage will show you audibly just how changing the control voltage amount affects the FILTER. The intonation will change as you vary the amount of voltage from the keyboard. Full keyboard voltage should yield a normal tempered scale.

Experiment with moving the CUTOFF control while you're playing the FILTER. Also, notice the effect of running NOISE into the FILTER when the EMPHASIS amount is up to the point of oscillation and the keyboard is controlling it: you get tuned NOISE.

CONTOUR AMOUNT

The CONTOUR AMOUNT control (8.4) is simply an attenuator for the control voltage generated by the FILTER's CONTOUR GENERATOR (8.5), which gets applied to the CUTOFF frequency. Going back to the basic patch we've been working with, you'll notice that it's possible to mimic the effect of the CUTOFF control with the CONTOUR AMOUNT control.

CONTOUR AMOUNT CONTROLS

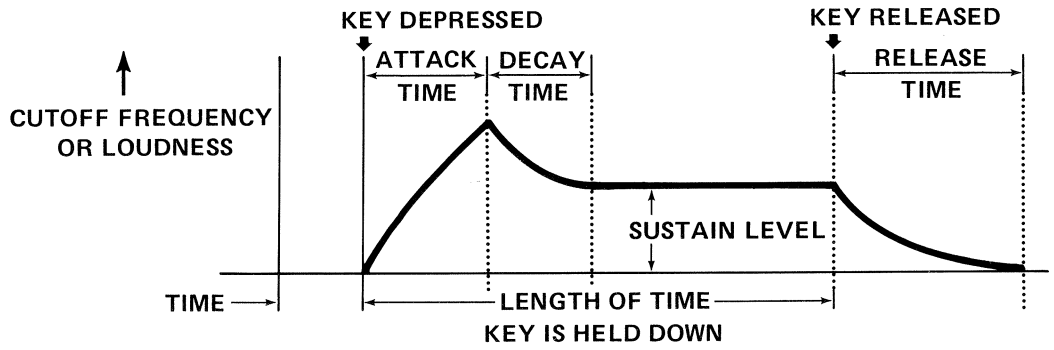


HOLD A LOW NOTE. MOVE THE CONTOUR AMOUNT CONTROL. NOTICE THAT WITH THESE SETTINGS, IT HAS THE SAME EFFECT AS THE CUTOFF CONTROL.

Changing the settings of the CONTOUR controls (8.5) will have a noticeable effect on this. To understand what's happening, you have to understand what the CONTOUR GENERATORS do.

THE CONTOUR GENERATORS

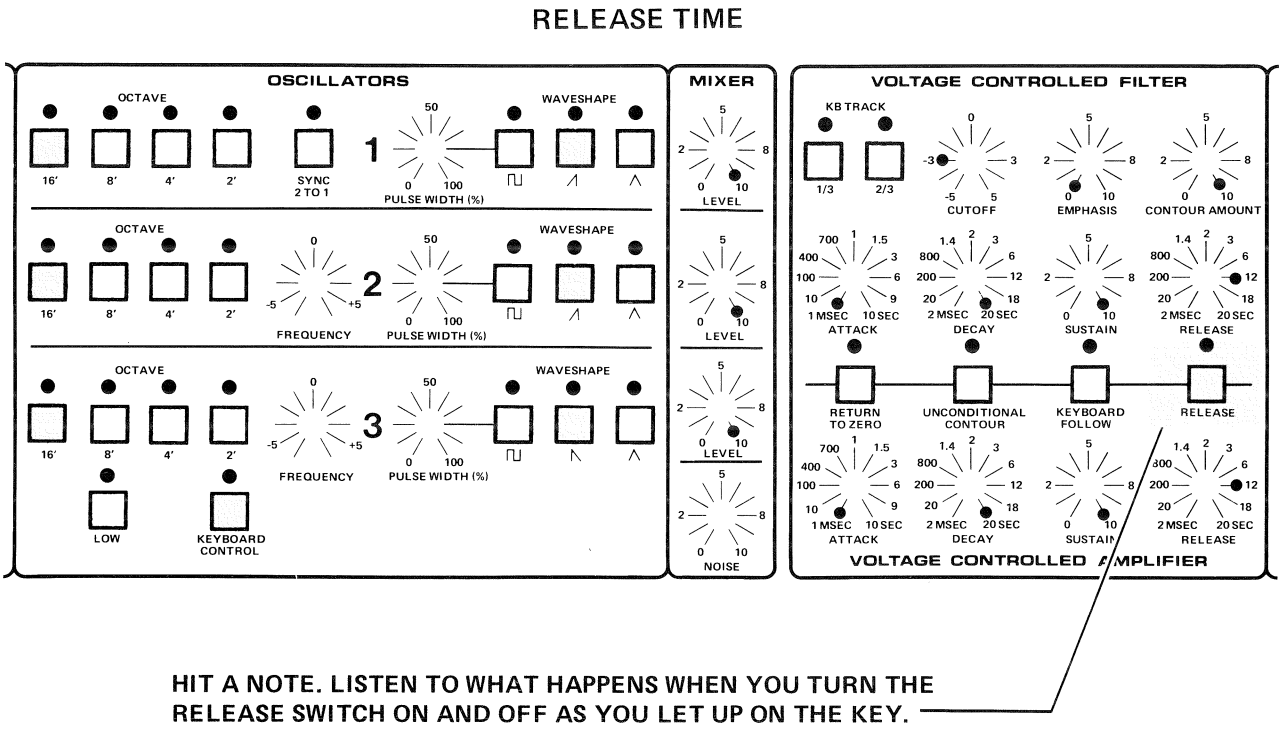
As was explained in the section on the keyboard, when you play a note, a trigger signal is generated by the keyboard which is channeled to the CONTOUR GENERATORS (8.5 and 9.0). It is this trigger signal which tells the CONTOUR GENERATORS to start up. Once triggered, the CONTOUR GENERATORS put out a *dynamic* control voltage — one that varies across time. When this voltage is applied to the CUTOFF control of the FILTER, you get dynamic changes in timbre. When it's applied to the VOLTAGE-CONTROLLED AMPLIFIER (9.0), you get dynamic changes in loudness.

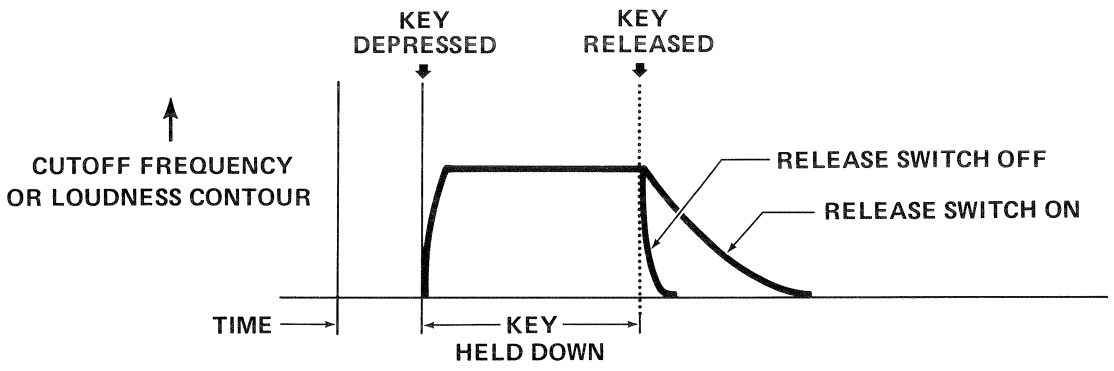


Other terms for CONTOUR GENERATOR are ENVELOPE GENERATOR, or ADSR, short for Attack, Decay, Sustain and Release – the four stages of the CONTOUR GENERATOR. As you can see from the above diagram, the attack time is the time it takes for the CONTOUR to reach its peak once a trigger signal has been received. From there the decay stage begins. Decay is the time it takes for the peak of the attack to subside to the sustain level – the level the CONTOUR maintains until the key is released. When you let up on a key, or release it, the CONTOUR goes into its release state which, depending on how the release time is set, can cause the note to ring out or cut off abruptly.

There are two ADSR CONTOUR GENERATORS in each voice of the Memorymoog. The filter contour output is applied to the CUTOFF of the FILTER. The second's output is applied to the VOLTAGE-CONTROLLED AMPLIFIER. Both ADSRs have the same characteristics: attack time is variable from 1 millisecond to 10 seconds; decay time is variable from 2 milliseconds to 20 seconds; sustain level is continuously variable from 0 to 10; and the release time is variable from 2 milliseconds to 20 seconds.

It's important to note that the RELEASE SWITCH (10.4) has to be on in order for the release portion of the CONTOUR to function. The RELEASE FOOTSWITCH (15.1) serves as a remote on/off control for the RELEASE SWITCH. It functions in the same way that a piano's sustain pedal works– down, the release is on; up, the release is off. However if the program is set up with the release on, the first time the pedal is depressed, the RELEASE will be turned off; from that point the footswitch will operate as described above. Try this patch: switch the RELEASE on and off and note the change in the sound when a key is released.





With the two ADSR CONTOUR GENERATORS, it's easy to see that there are many possible combinations of settings. Experiment. At first, try setting both CONTOUR GENERATORS the same way so that the effect of each control is obvious. As you get more familiar with the controls and their effects, try different combinations. Maybe a slow attack on the FILTER and a fast attack on the AMPLIFIER. Maybe a high sustain and release on the FILTER. The possibilities are virtually endless.

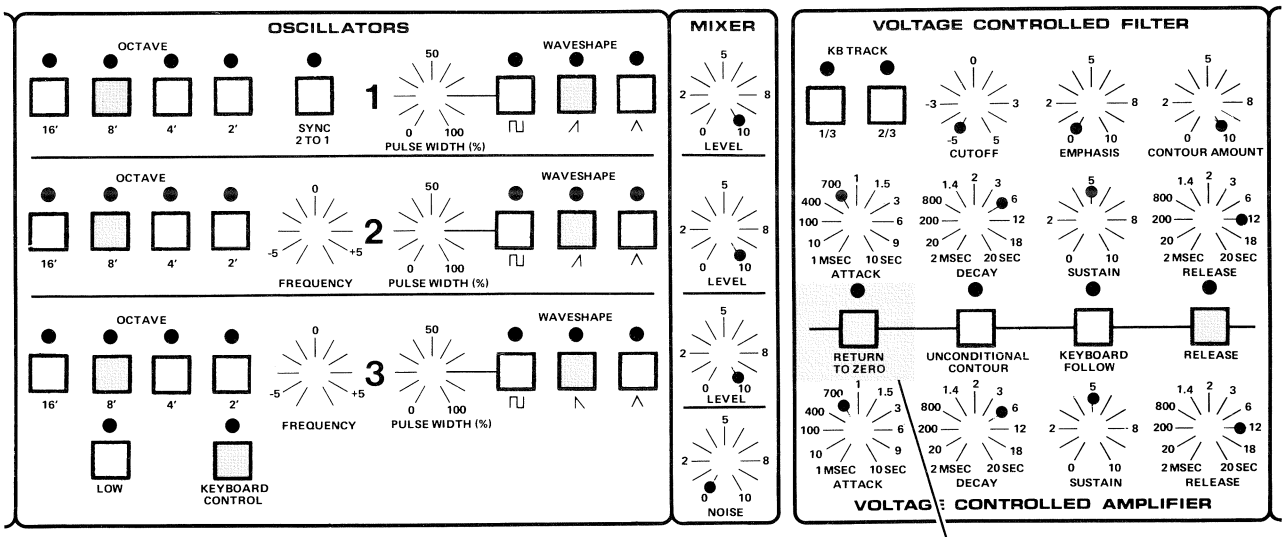
Also note that unless you have the CONTOUR AMOUNT control (8.4) turned up, the FILTER's CONTOUR GENERATOR will not control the CUTOFF simply because the CONTOUR AMOUNT control attenuates (limits) the signal from the CONTOUR GENERATOR. When it's set at 0, no control voltage is let through.

CONTOUR MODE CONTROLS

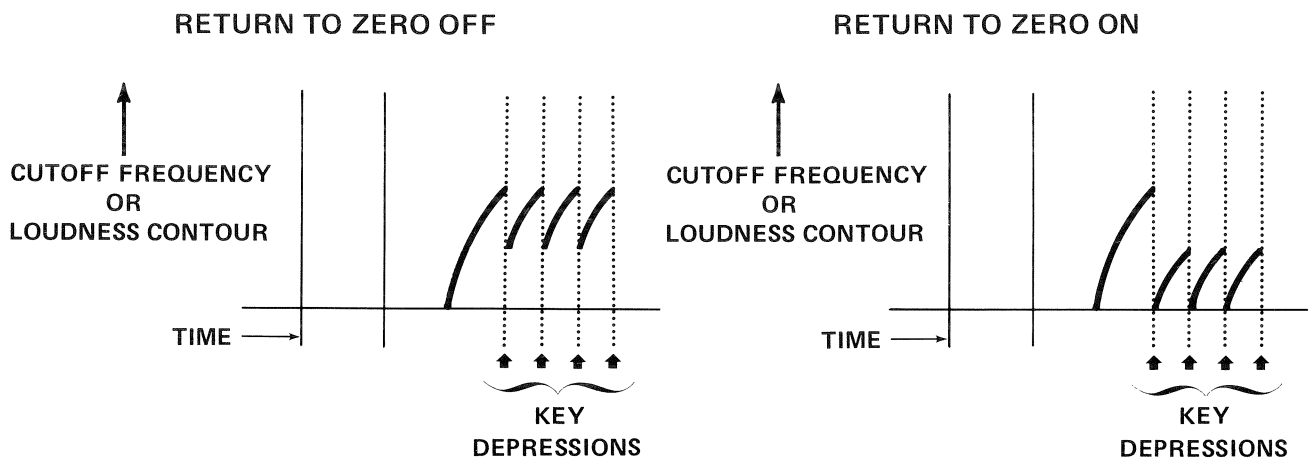
In between the two sets of ADSR controls are four switches (10.0), one of which is the RELEASE SWITCH (8.9), mentioned above. These switches affect both CONTOUR GENERATORS.

RETURN TO ZERO (10.1) governs the way that the attack time responds when triggers are sent to the same voice repeatedly before the entire ADSR cycle has been completed. With this switch off, striking a note repeatedly (make sure you're in a KEYBOARD MODE [1.7] with MEMORY – KB MODE 2 or 4) will cause the attack time to start from the level it had attained before the new trigger was received. With the switch on, retriggering a voice at any time during the attack stage will reset the voltage to zero and start the contour over from the beginning.

CONTOUR RETURN TO ZERO



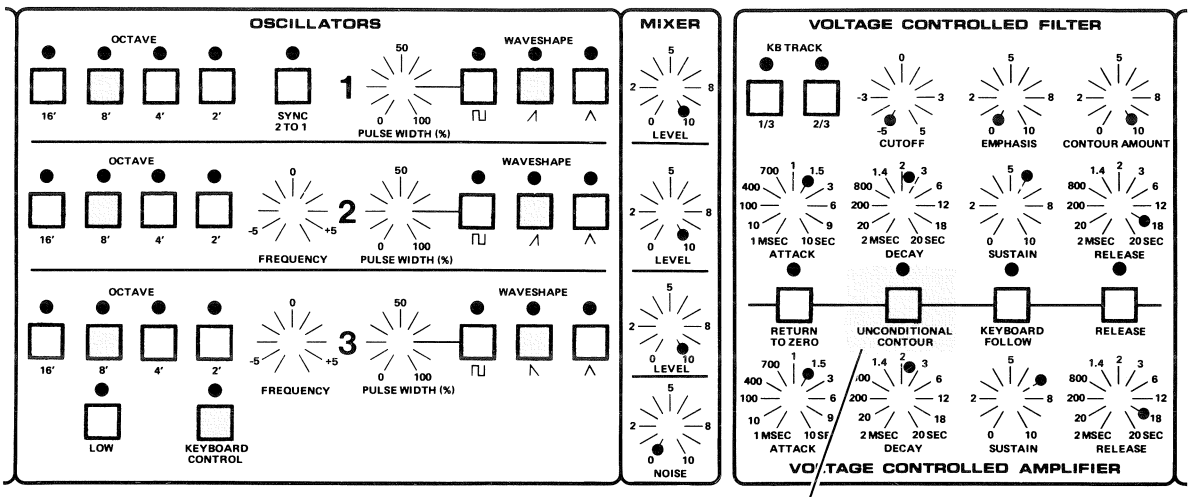
PLAY A LOW NOTE REPEATEDLY, ABOUT TWICE A SECOND. TURN THE RETURN TO ZERO SWITCH ON AND OFF TO HEAR THE DIFFERENCE. IT'S SUBTLE – LISTEN CLOSELY. PLAY CHORDS TO GET ANOTHER PERSPECTIVE.



UNCONDITIONAL CONTOURS

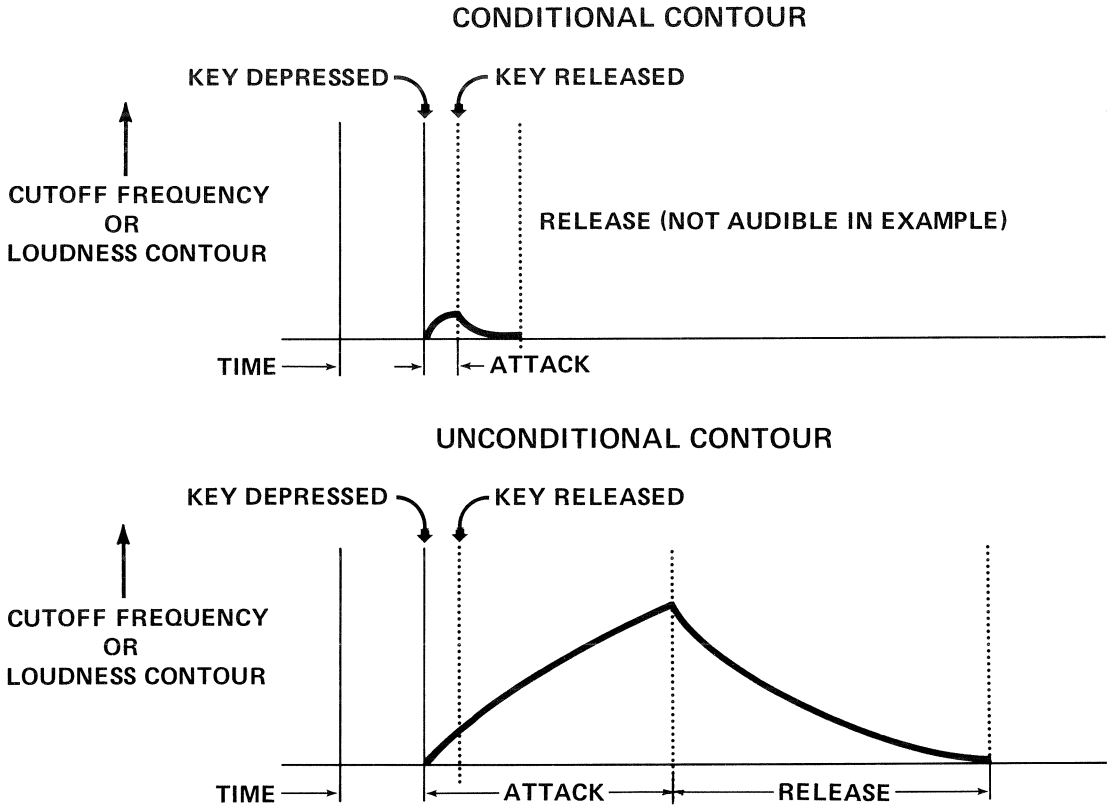
The UNCONDITIONAL CONTOUR switch (10.2) governs the way the attack and release stages of the CONTOUR GENERATORS act. In the CONDITIONAL state (with the switch off), the release stage comes in immediately upon the release of a key, regardless of how far along the contour has gotten. In the UNCONDITIONAL state (with the switch on), if you hit a note, the attack stage will complete itself and then go immediately into the release stage whether you're holding down the note or not. The fact that the attack stage completes itself without your having to hold down the note enables you to set up long attack times, play a note or notes on the keyboard, start playing another keyboard instrument, and have what you played on the Memorymoog fade in and out.

UNCONDITIONAL CONTOUR



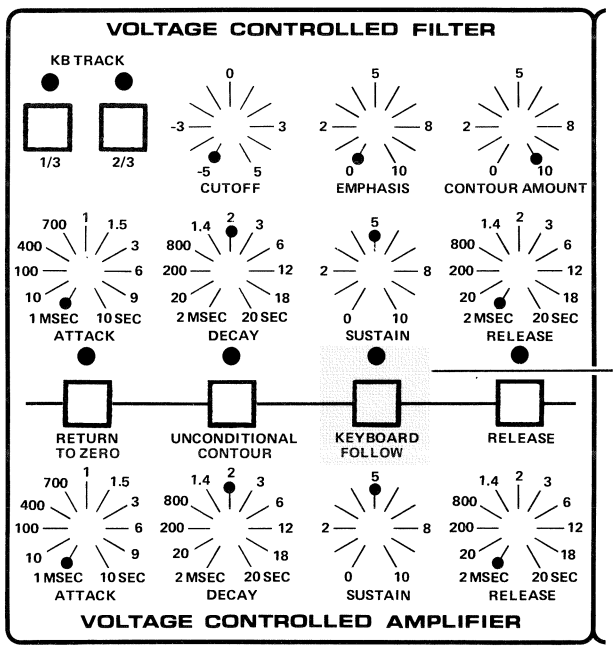
PLAY ONE NOTE QUICKLY WITH THE SWITCH OFF. YOU WON'T HEAR THE NOTE; WITH IT ON, THE NOTE WILL FADE IN.

Set up the CONTOURS like this and play a note on the keyboard quickly. With the UNCONDITIONAL switch off, if you play fast enough, you won't hear the note at all. With the UNCONDITIONAL switch on, the note will fade in even after you've let up on the note.



KEYBOARD FOLLOW

With the CONTOUR GENERATORS set up like this:



KEYBOARD FOLLOW

TURN SWITCH ON/OFF. PLAY CHROMATIC SCALE, HOLDING NOTES DOWN MOMENTARILY. NOTICE HOW LOW NOTES SUSTAIN LONGER THAN HIGH NOTES WITH THE SWITCH ON.

play a chromatic scale up the keyboard, first with the KEYBOARD FOLLOW switch (10.3) off, and then with it on. Hold the notes down a bit. When you have the KEYBOARD FOLLOW switch on, notice that the lower notes seem to sustain longer than the higher ones. That's because the KEYBOARD FOLLOW switch causes the attack, decay, and release times of the CONTOURS to get proportionally shorter as you play higher on the keyboard. This mimics the sustain properties of acoustic instruments like the piano and guitar in that their higher notes have less sustain than their lower notes.

Experimenting with CONTOUR GENERATOR settings is an important part of learning to create your own sounds with a synthesizer. CONTOURS or ENVELOPES are a major portion of what gives a sound character and individuality. In your experimenting, here are some rules of thumb you should keep in mind:

A CONTOUR must allow sound to pass, otherwise you will not be able to hear anything from your instrument.

If the VOLTAGE-CONTROLLED AMPLIFIER's CONTOUR is set up with decay and sustain settings as short and small as possible, sounds will be very percussive, no matter how the filter is set.

Short decay times coupled with long attack times will make reverse sound effects.

Release settings will be meaningless unless the RELEASE SWITCH (10.4) is on or the RELEASE FOOTSWITCH (15.1) is held down.

Release times will not affect the sound unless the sustain level is set high enough.

The filter will not be affected by its CONTOUR GENERATOR unless the CONTOUR AMOUNT control (8.4) is turned up.

No sound may be heard if the FILTER CUTOFF (8.2) and the CONTOUR AMOUNT (8.4) controls are not up high enough to pass any sound.

Long attack times will give the impression that nothing is happening unless you hold notes long enough, or unless you have the UNCONDITIONAL CONTOUR switch (10.2) on.

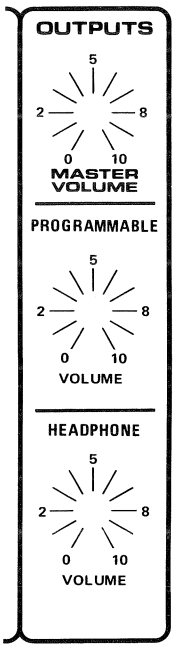
The attack phase can be varied using the RETURN TO ZERO switch (10.1).

OUTPUTS

The MASTER VOLUME control (11.1) affects the overall output level of the Memorymoog. It is a non-programmable control. It should be set as high as possible to ensure a good signal-to-noise ratio. Note that this control sets the limits of PROGRAMMABLE FOOTPEDAL # 1 (4.1) when it's set to control volume.

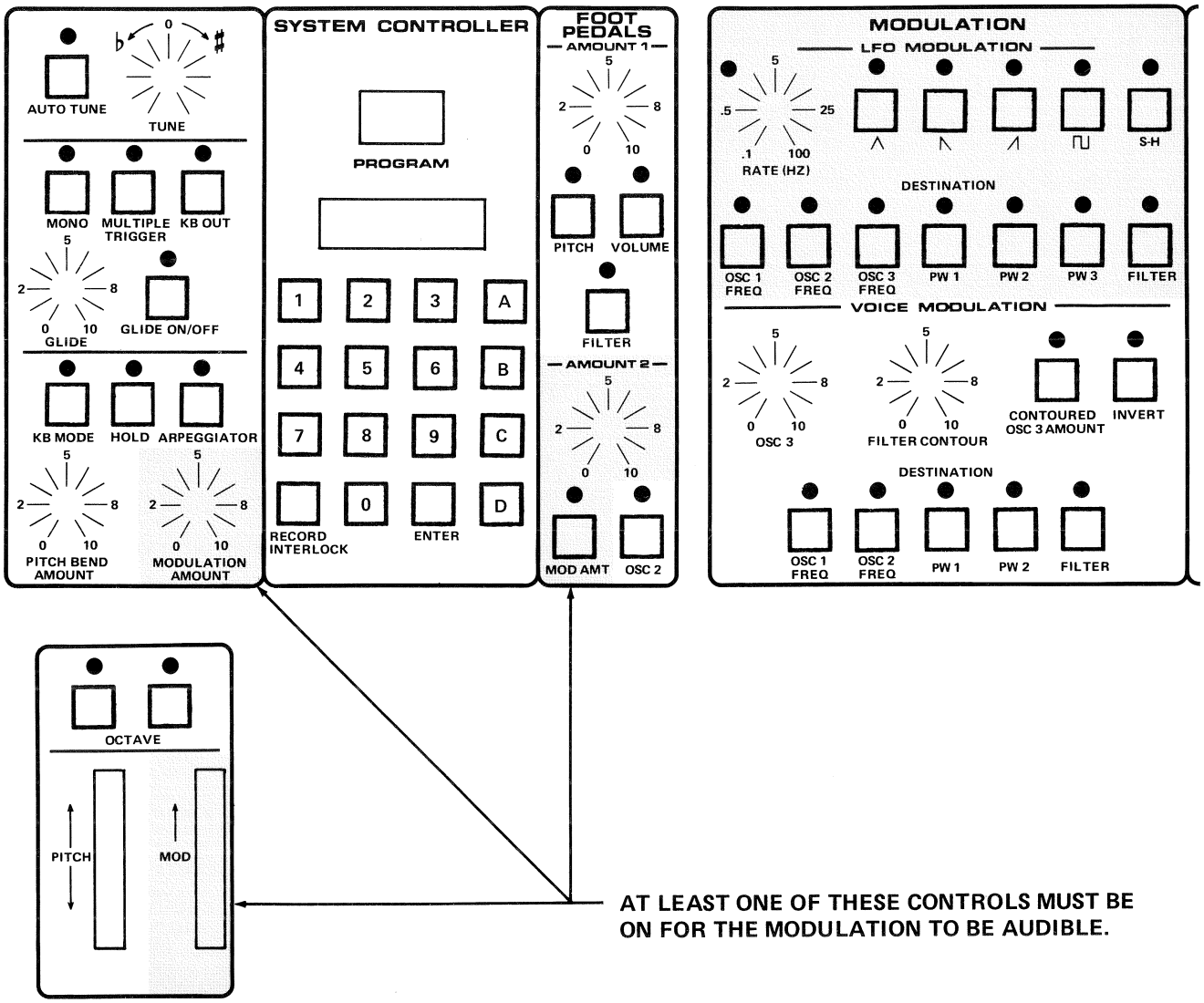
The PROGRAMMABLE VOLUME control (11.2) is used to adjust the volume levels so that they are evenly matched. You can use this control to balance quiet patches with louder ones so that you don't have to fiddle with the MASTER VOLUME control every time you change a preset.

The HEADPHONE VOLUME control (11.3) is used to vary the output level to a pair of stereo 8Ω headphones, which can be plugged in at the front right of the instrument at the key block.



MODULATION

Modulation is the process of varying a sound source, or a sound modifier, to change the character of the sound. In the Memorymoog, the sound sources are the OSCILLATORS and NOISE SOURCE, and the modifier is the FILTER. There are three sources of modulation: the LFO (low-frequency oscillator), OSCILLATOR 3, and the FILTER CONTOUR GENERATOR.

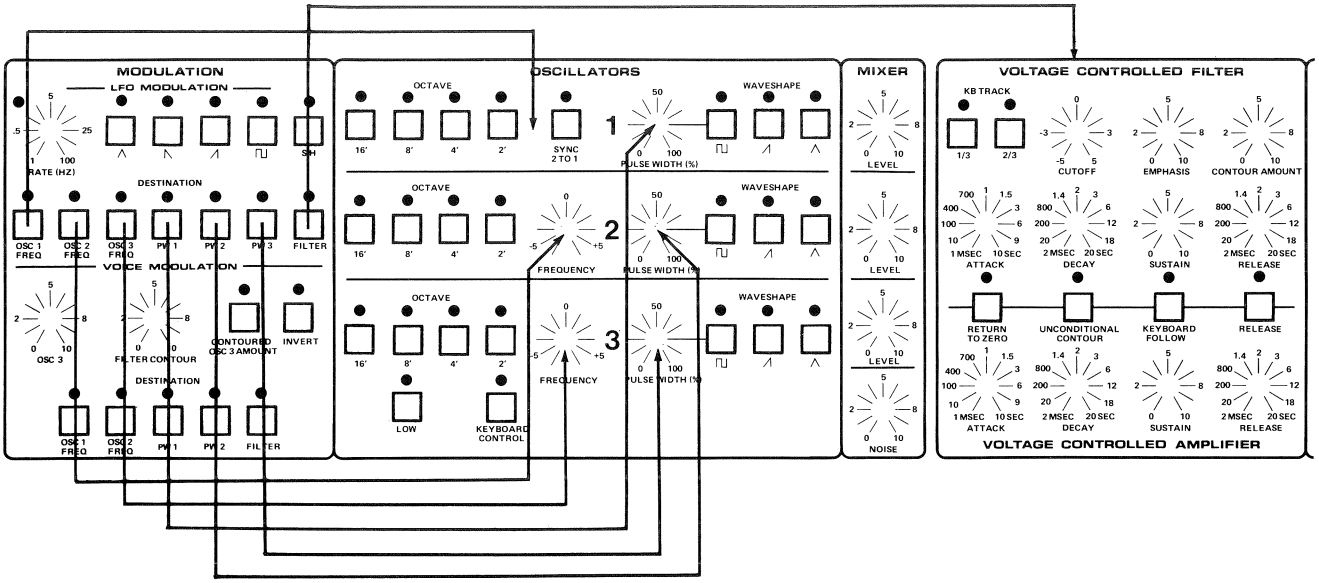


LFO MODULATION

The low-frequency oscillator (5.0) serves a dual function in the Memorymoog: it is a source of modulation for creating effects like vibrato and filter sweeping, and it is the internal clock for the ARPEGGIATOR (1.9). In its role as a modulation source, it produces triangle ⋀ , positive-going sawtooth ◿ , negative-going sawtooth ◺ , square ⊓ , and sample and hold (random) waveshapes. When these waveshapes are applied to the oscillators, the filter, and/or the pulse widths of the three oscillators, various useful and interesting effects can be produced.

At least one of the following controls *must* be on for modulation from the LFO to be audible: the MODULATION WHEEL (2.3); the MODULATION AMOUNT control (1.11); and/or the FOOT-PEDAL MOD AMOUNT controls (4.2). If none of these is on, no modulation will be heard.

LFO MODULATION DESTINATIONS

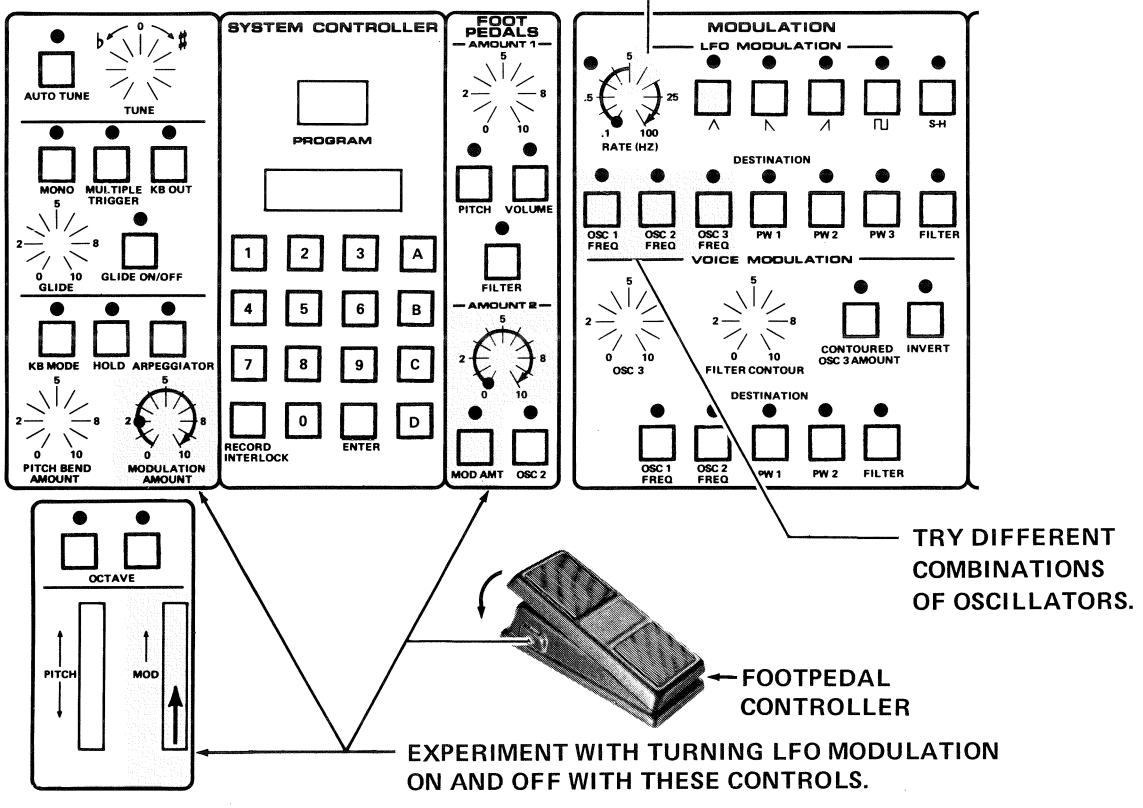


The above diagram shows the possible destinations for the LFO's control voltage. It can be used to sweep the pitch of the oscillators individually, in pairs, or simultaneously. It can sweep the oscillators' pulse widths and/or it can sweep the filter's CUTOFF frequency.

When you modulate the pitch of the oscillators with a triangle wave, you can create vibrato. The LFO RATE control (5.1) adjusts its speed. Try this setting of the LFO, experimenting with controlling first one oscillator, then two, then all three:

LFO-CREATED VIBRATO

LISTEN TO THE EFFECT THE RATE CONTROL HAS.
VIBRATO IS CREATED IN THE RANGE OF THE SHADED AREA.

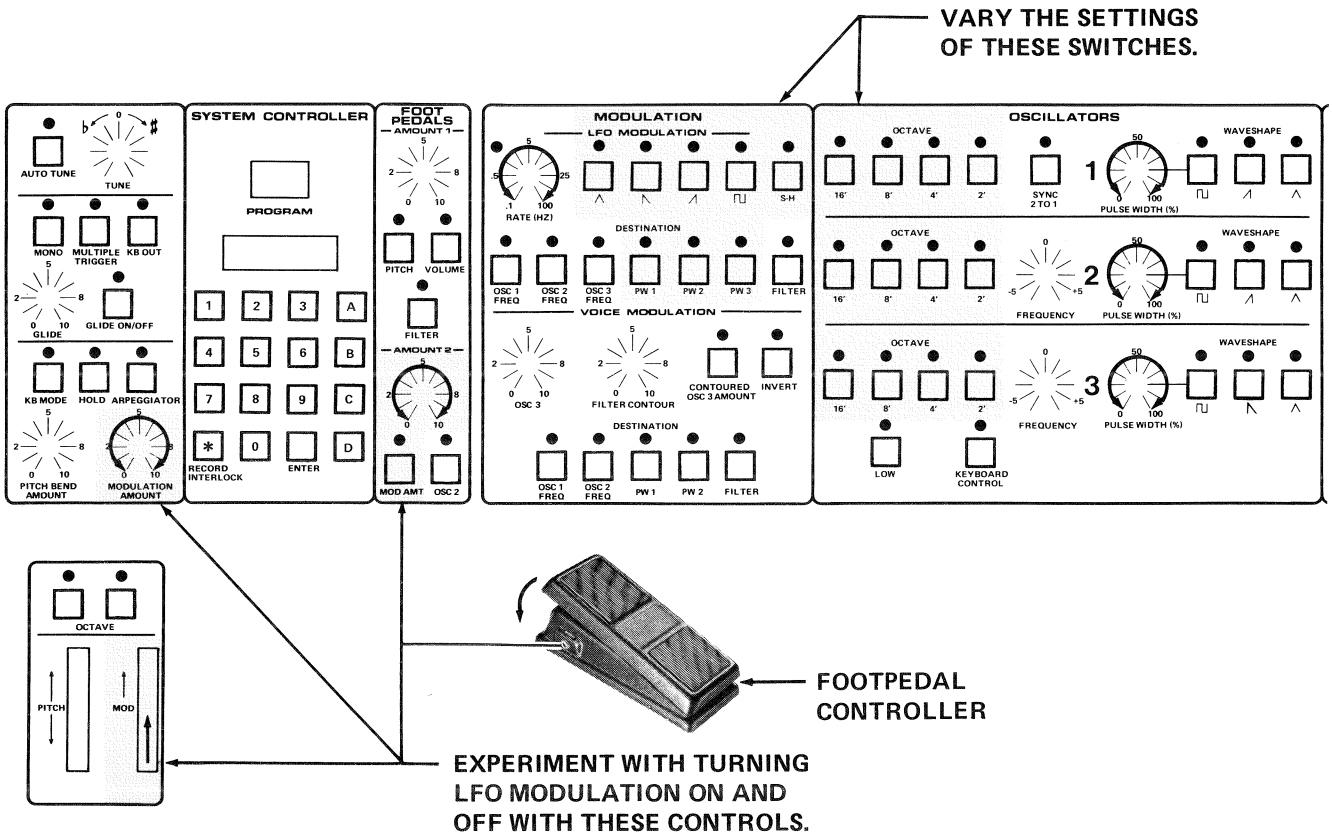


Note what effects the different settings of the various MODULATION AMOUNT controls (2.3, 1.11, and 4.2) have, both on the sound of the modulation effect and on each other. The WHEEL (2.3) adds to the MODULATION AMOUNT controls (1.11 and 4.2), as does the FOOTPEDAL CONTROLLER (13.2).

Listen to the same LFO MODULATION setting with all the different waveshapes — positive- and negative-going sawtooths, square, and S-H (sample and hold random). The sawtooth waves produce glides up or down in pitch; the square wave produces trills which can be tuned by the AMOUNT controls; and the sample and hold produces randomized pitch shifts.

You can get some interesting effects when you use different waveshapes from the LFO to modulate the pulse widths of the three oscillators. When you change the width of a pulse wave, you're changing its harmonic content and therefore its timbre. By slowly sweeping the widths of different combinations of pulse waves you can get phasing-like sounds, string sounds, and so on. The key to this technique is experimentation. Try different LFO speeds, different LFO waveshapes, different pulse widths and different pulse widths at different octaves.

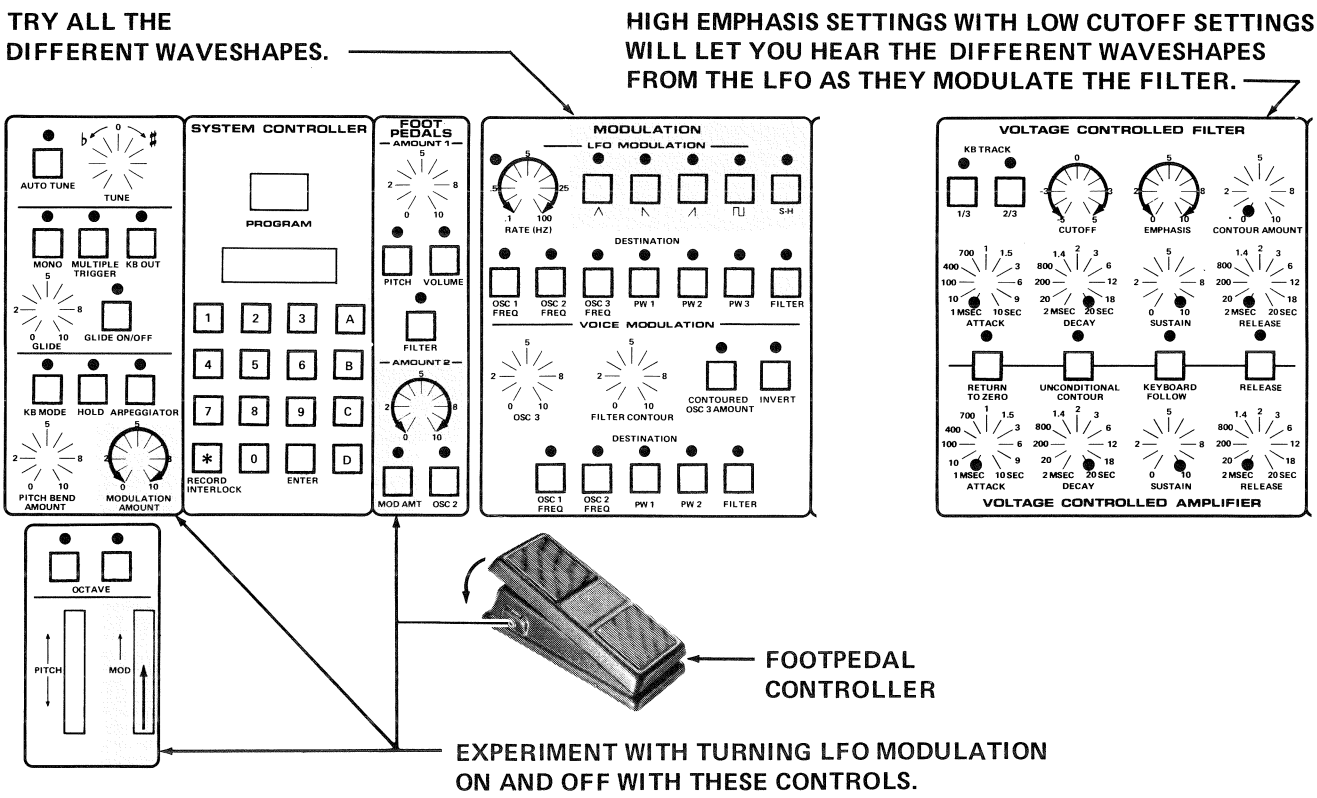
LFO PW MODULATION



When modulation is applied to the FILTER, it affects the FILTER CUTOFF FREQUENCY (8.2). There are many useful sounds created by FILTER MODULATION. A triangle wave can give you nice slow swells. Sawtooth waves give you reiteration effects. Positive-going sawtooths open the FILTER up (the sound gets brighter as the FILTER opens). Negative-going sawtooths close the FILTER down (the sound gets more muted as the FILTER closes). A square wave will give you a bright/muted sound which alternates as the waveshape goes through its cycle — momentarily high, momentarily low.

Sample and hold will randomly percolate. Again, experiment with different modulation speeds, waveshapes, and different amounts of modulation. Try modulation with a high FILTER EMPHASIS setting. Change the CUTOFF. Remember, it's possible to open the CUTOFF control so far that you won't hear any modulation effect. If you start adding CONTOUR shapes to the FILTER while it's being modulated from the LFO or some other source (such as a voltage pedal), it's possible to drive the CUTOFF frequency so high that you won't hear any modulation. If, in your fiddling around with knobs and dials, you suddenly get no modulation, turn the CUTOFF control counterclockwise. If that doesn't help, make sure you've turned up one of the three possible MODULATION AMOUNT controls (the MODULATION WHEEL [2.3], the MODULATION AMOUNT control [1.11], and/or PROGRAMMABLE FOOTPEDAL # 2 [4.2]).

LFO FILTER MODULATION



Some rules of thumb about modulation:

Triangle waves are used to create vibrato when applied to the oscillators at a rate between about 5 and 20Hz.

Pulse width modulation is useful for creating string sounds, which require a lot of phasing and motion in them. It is also possible to "turn on" and "turn off" an oscillator by modulating its pulse width from or to 0% (only the pulse wave should be on if you're trying to do this).

If the rate is slow enough while modulating an oscillator(s), you can hear the waveshape of the LFO. The faster the rate of modulation, the more clangorous the sound.

When modulating the filter, it's possible to have the CUTOFF frequency so high as to not be able to hear any modulation at all.

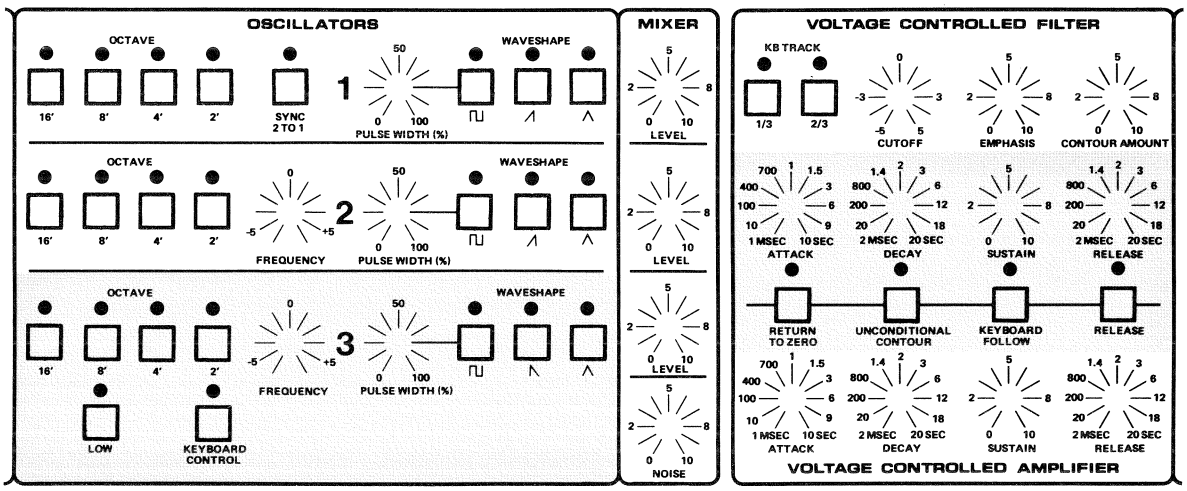
Square wave modulation of the oscillators is used to create trills, which can be tuned with the modulation amount controls.

Positive-going sawtooth waves raise the pitch of the oscillators and open the filter's CUTOFF. Negative-going sawtooth waves lower the pitch of the oscillators and close the filter's CUTOFF.

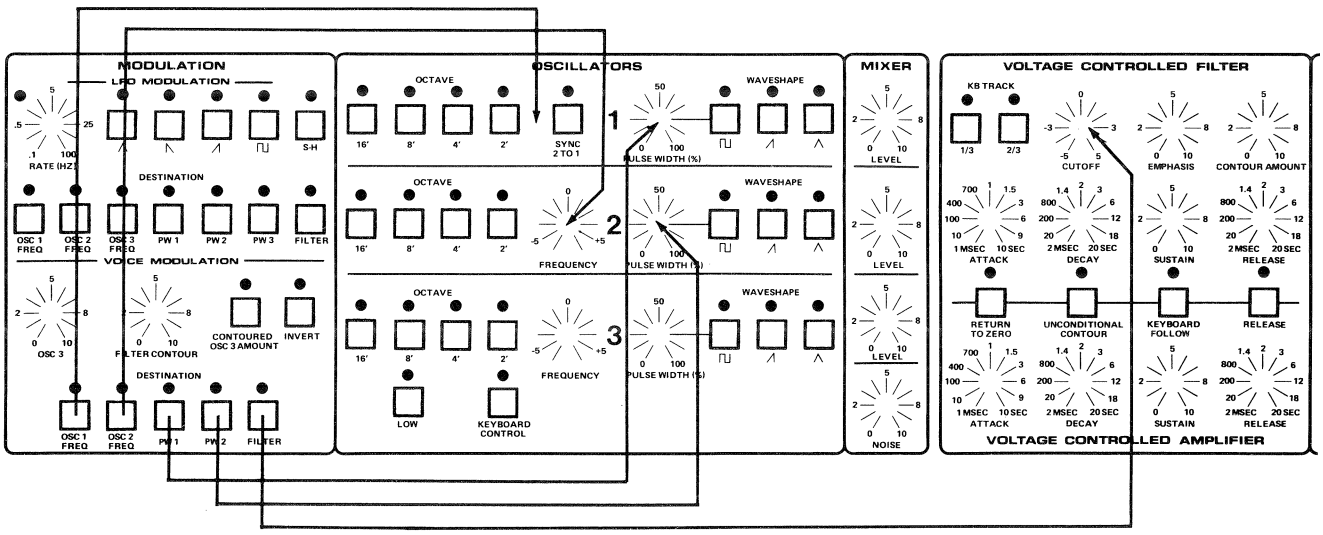
VOICE MODULATION

The two sources of VOICE MODULATION are the filter's CONTOUR GENERATOR and OSCILLATOR 3. Any function that changes or modulates these two sources will in turn be reflected in the character of voice modulation sent to the various possible destinations.

VOICE MODULATION SOURCES

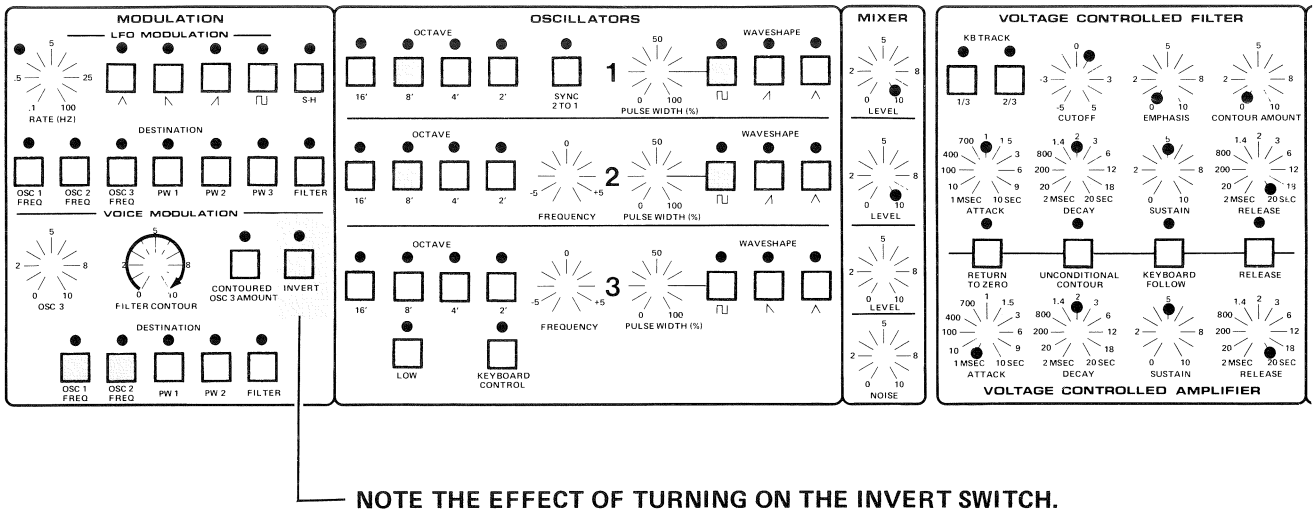


DESTINATIONS OF THE VOICE MODULATION



The major distinction between LFO and VOICE MODULATION is that there is only one master LFO, while there is an entirely different situation with VOICE MODULATION. Since there are six filter CONTOUR GENERATORS (one for each of the six voices), every time you trigger one of the six, you get control voltages that vary with time. These voltages can be applied to the frequency and/or the pulse widths of the first two oscillators, and/or to the filter's CUTOFF frequency of that voice. To hear this effect set up the following patch:

FILTER CONTOUR VOICE MODULATION

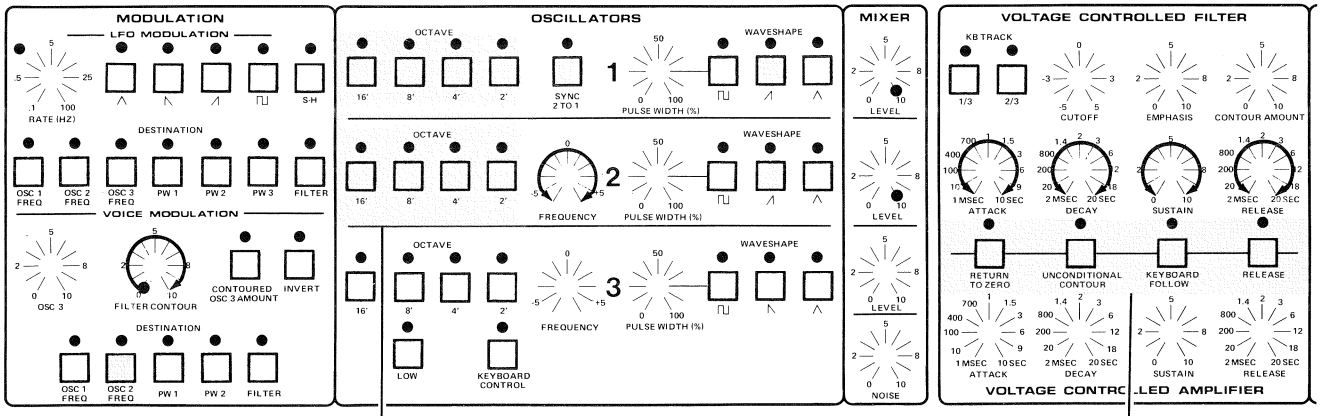


NOTE THE EFFECT OF TURNING ON THE INVERT SWITCH.

Change the destination switches to hear the effect of modulating the different destinations with a contour. Notice that when you play more than one note, each has its own distinct and independent CONTOUR.

Some of the most common SYNC sounds are created by modulating the frequency of OSCILLATOR 2 with the FILTER CONTOUR while OSCILLATOR 2 is SYNCED to OSCILLATOR 1. Experiment with this patch, changing the frequency of OSCILLATOR 2 with its frequency control (6.5), changing its octave setting, adjusting the CONTOUR controls to all sorts of different shapes, trying various CONTOUR MODE switches (10.0) . . .

VOICE MODULATION SYNC EFFECTS

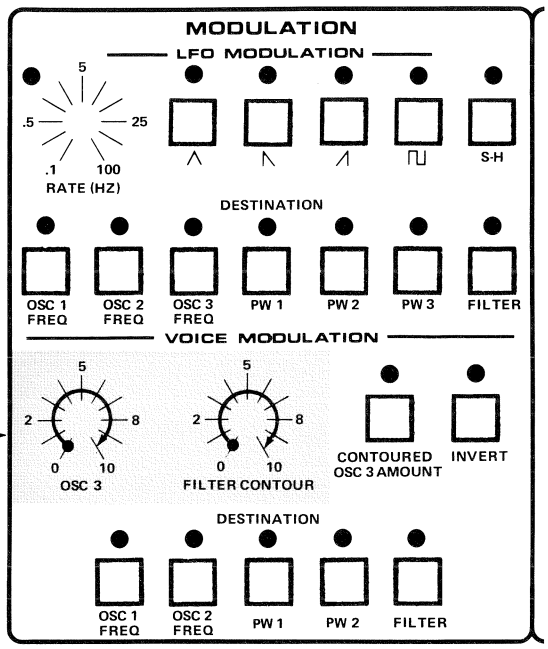


EXPERIMENT WITH VARYING THESE SWITCHES.

You can also invert (turn upside down) the filter CONTOUR's voltage by using the INVERT switch (5.8). Note the effect that using this switch has on the way the CONTOUR affects pitch.

Remember that no VOICE MODULATION will be heard unless one of the two VOICE MODULATION AMOUNT controls (5.5 and 5.6) is turned up and you have at least one DESTINATION switch (5.9) on.

VOICE MODULATION AMOUNT CONTROLS

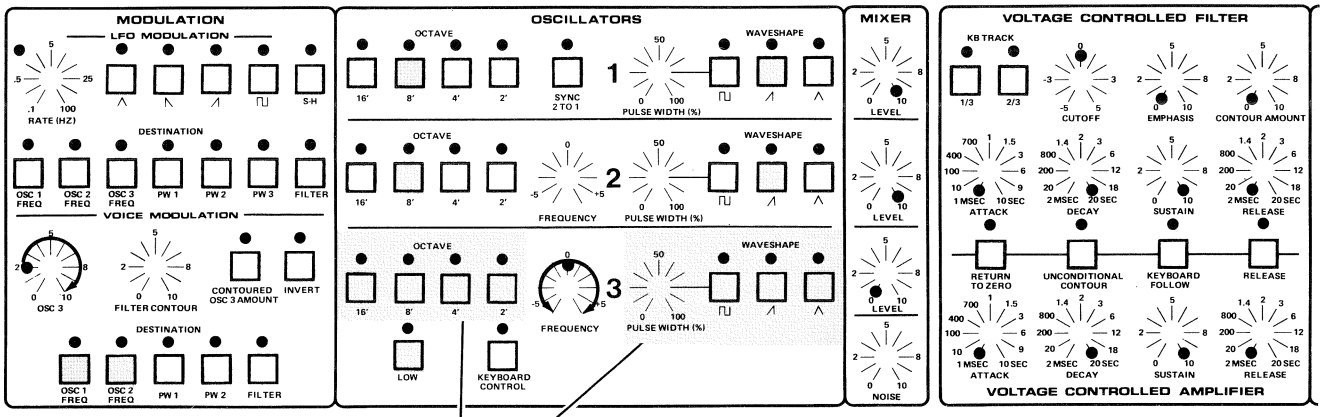


VOICE MODULATION AMOUNT CONTROLS

AT LEAST ONE HAS TO BE ON TO HEAR ANY VOICE MODULATION. ALSO, SOME DESTINATION HAS TO BE SWITCHED IN.

Just as there are six FILTER CONTOUR GENERATORS, there are six OSCILLATOR 3s (one for each voice card). These can be used as voltage sources for the VOICE MODULATION section. OSCILLATOR 3 can operate in both audio and sub-audio ranges (below the threshold of hearing, like an LFO). Keyboard control of OSCILLATOR 3 can be switched in and out. When it's not being controlled by the keyboard, OSCILLATOR 3 acts as a full-range modulation oscillator, a sort of super LFO. Set up this patch and listen to the effects of OSCILLATOR 3 as a modulation oscillator:

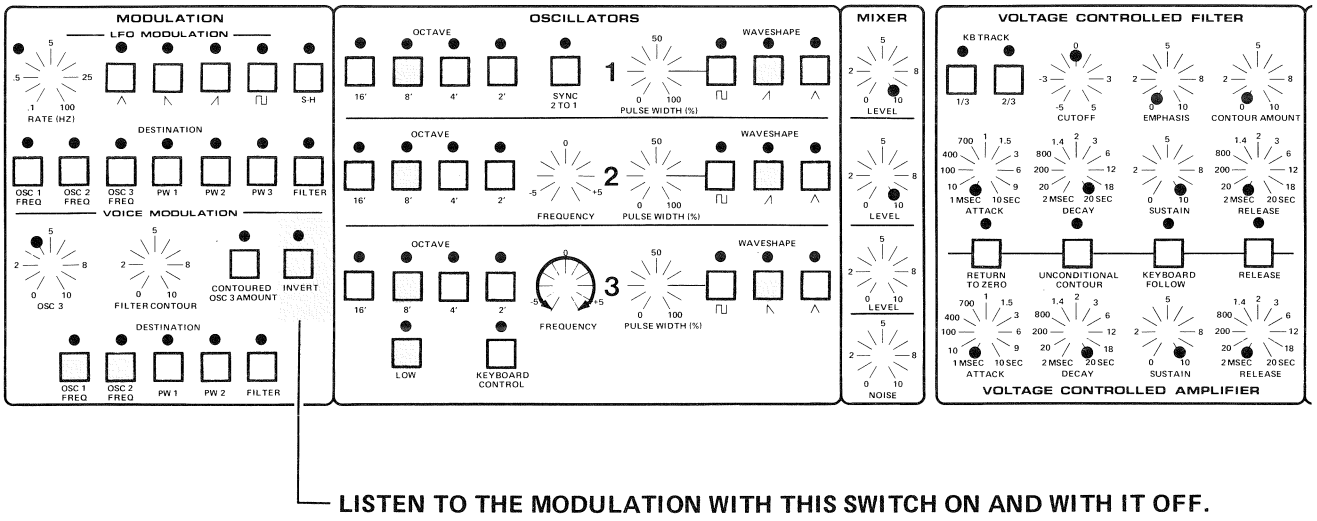
OSCILLATOR 3 AS AN LFO



TRY DIFFERENT OCTAVE SETTINGS, DIFFERENT WAVESHAPES AND COMBINATIONS OF WAVESHAPES.

The INVERT switch (5.8) will have a very noticeable effect on the sawtooth waveshape from OSCILLATOR 3. Set up this patch:

INVERTING THE SAWTOOTH WAVESHAPE FROM OSCILLATOR 3

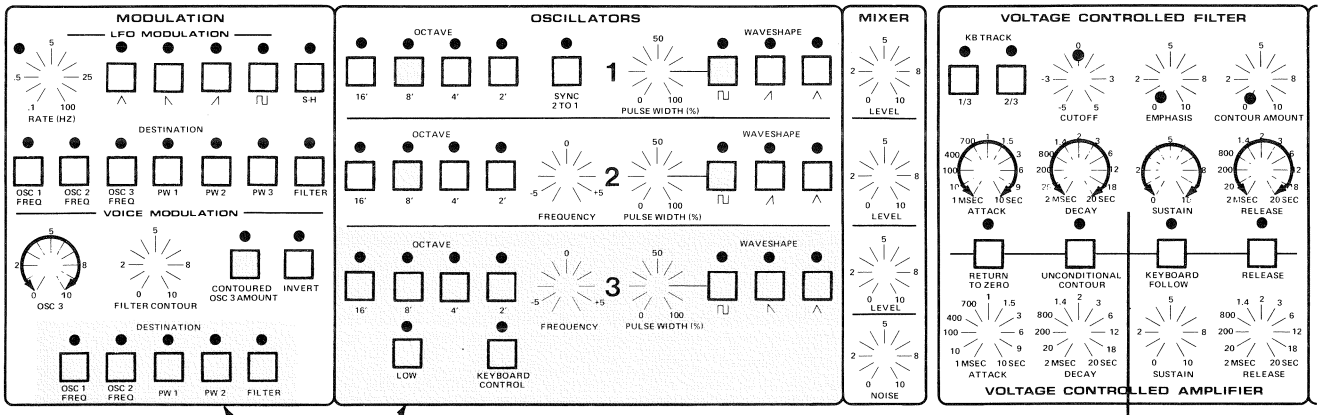


LISTEN TO THE MODULATION WITH THIS SWITCH ON AND WITH IT OFF.

Play a note on the keyboard. Now turn the INVERT switch on and off, listening to the modulation in each case. The INVERT switch inverts the waveshapes so that both positive- and negative-going sawtooths are available from OSCILLATOR 3.

Another thing you can do with the VOICE MODULATION section is use the FILTER's CONTOUR GENERATOR to control the amount of OSCILLATOR 3 modulation. This lets you vary the amount of OSCILLATOR 3 modulation across time, using the CONTOUR controls. Try this patch to hear the effect:

CONTOURED OSCILLATOR 3 MODULATION



NOTE THE EFFECT OF DIFFERENT CONTOUR SHAPES ON THE AMOUNT OF OSCILLATOR 3 MODULATION.

EXPERIMENT WITH DIFFERENT SETTINGS.

There's no law against using OSCILLATOR 3's KEYBOARD CONTROL function while OSCILLATOR 3 is acting as a modulation oscillator. Using the KEYBOARD CONTROL switch (6.8) while the LOW switch (6.7) is on will give you modulation effects whose speed will vary in relation to where you are playing on the keyboard: high notes produce fast modulation; low notes produce slow modulation. With the LOW switch off, you'll be applying audio frequencies as modulation voltages. This effect is characterized by buzziness and grit.

You should try combining both OSCILLATOR 3 and the FILTER CONTOUR as VOICE MODULATION sources. Experiment in every way you can think of to familiarize yourself with your instrument. When you run out of ideas, just turn knobs and dials until you come across a sound you like. Then retrace how it's being created and store the knowledge in the back of your mind for future reference. The best way to get to know an instrument like the Memorymoog is to use it.

Some rules of thumb about VOICE MODULATION:

At least one of the two VOICE MODULATION AMOUNT controls (5.5 and 5.6) has to be turned up to hear any modulation effect.

At least one of the five DESTINATION switches (5.9) has to be on to hear any modulation.

The INVERT switch turns the FILTER CONTOUR and OSCILLATOR 3 waveshapes upside down.

In order for the pulse width modulation to function, the oscillators have to be putting out pulse waves.

If the CUTOFF of the FILTER is up too high you won't hear any FILTER modulation.

If you have too much control voltage going to the FILTER, you will drive the CUTOFF frequency so high that you won't hear modulation anymore.

Positive-going sawtooths cause the pitch of an oscillator to rise and the CUTOFF of the FILTER to open. Negative-going sawtooths cause the pitch of an oscillator to fall and the CUTOFF of the FILTER to close.

Pulse waves can be used for creating trills. These can be tuned by using the OSCILLATOR 3 MODULATION AMOUNT control (5.5). Varying the pulse width will vary the time between the up and down portions of the trill.

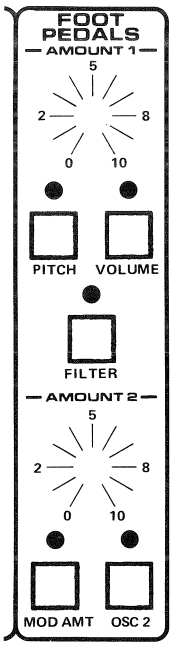
Pulse waves can be used to open and close the FILTER in an on/off, up/down manner.

Triangle waves can be used to create vibrato when applied to an oscillator. They can also create repetitive swells when applied to the FILTER, and phase shift when applied to pulse widths.

Audio frequency modulation, used subtly, can give timbres more bite.

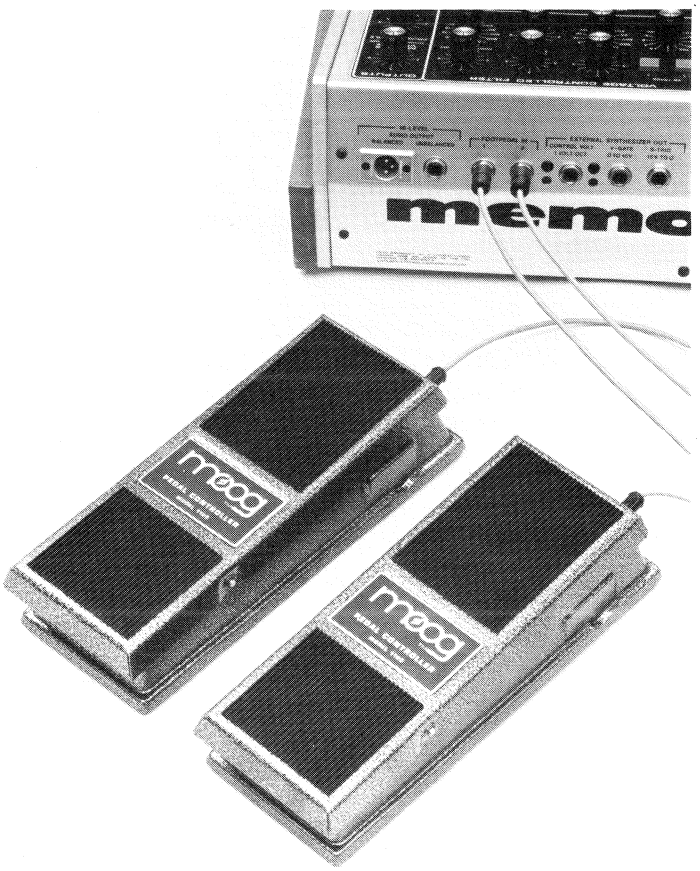
Using the FILTER CONTOUR to sweep the frequency of OSCILLATOR 2 when it's SYNCED to the frequency of OSCILLATOR 1 creates the strong dynamic timbral sounds that are often associated with the SYNC effect.

THE PROGRAMMABLE FOOTPEDALS



These are fairly self-explanatory. PEDAL 1 can be used to control the frequencies of the oscillators for pitch bending. The range of the bend effect can be tuned by using the rotary AMOUNT control. Volume and the CUTOFF frequency of the filter can be controlled in the same way. Note that when you're using the pedal to control the volume of the instrument, the extreme limit (the loudest the instrument can get) is set by the MASTER VOLUME control (11.1).

PEDAL 2 can be used as an LFO MODULATION AMOUNT control, just like the MODULATION WHEEL (2.3), and it can be used to control the pitch of OSCILLATOR 2. When used to adjust the LFO MODULATION AMOUNT, the pedal adds to the initial amount of modulation set up by the MODULATION AMOUNT control (1.11). In both functions — controlling the amount of modulation and sweeping the pitch of OSCILLATOR 2 — the AMOUNT control adjusts the range of the pedal.



Pedals aren't supplied with the instrument. They should be voltage pedals with a range of 0 to 5 volts, such as the Moog 1120 pedals. Your local music shop should have, or be able to order, suitable pedals. Note that if you have just one pedal, the inputs on the back of the Memorymoog are crosscoupled, meaning that if you plug in just one pedal, it will do the work of two. For example: a pedal is plugged into the PEDAL 1 input, but all the programs you've called up show that PEDAL 2 will control the modulation. PEDAL 1 will crosscouple so that it will control the modulation amount because there isn't a pedal connected to the PEDAL 2 jack.

MEMORYMOOG SOUND CHARTS

The following page shows the Memorymoog programs listed by title and category. Units shipped from the factory have the 10 program chains built with the 10 categories listed.

Factory programs for the Memorymoog were supplied by:

Don Airey
John Bezjian
Jeff Burger
Todd Booth
Wendy Carlos
Tom Coster
Herbert Deutsch
Larry Fast
Jan Hammer
Lee Hargrove
Nancy Kewin
Roger Luther
Dominic Milano
Val Podlasinski
Bob Wehrman
Rock Wehrmann
Bill Wolfer

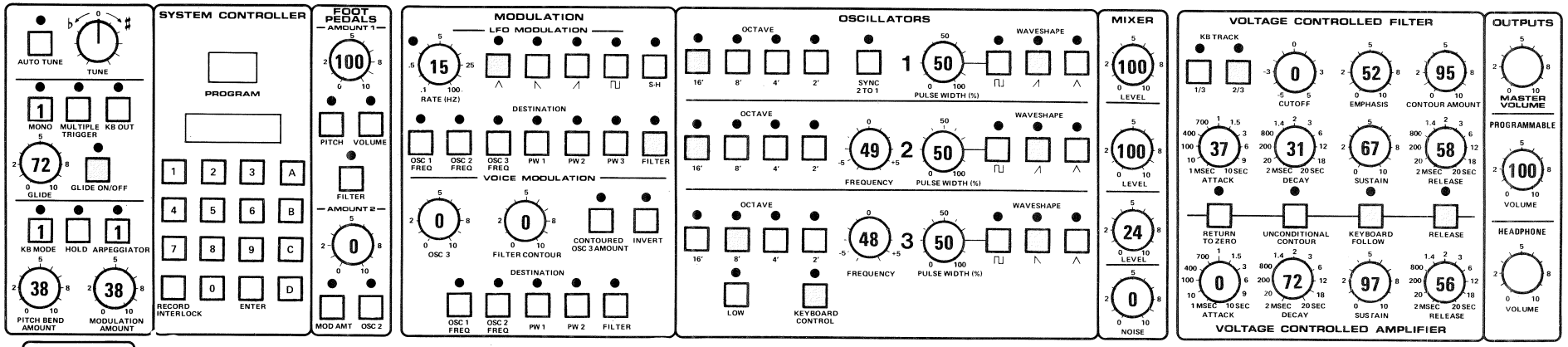
We would like to thank the countless people whose comments, suggestions and musical creativity have contributed to the making of the Memorymoog.

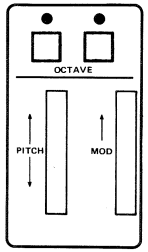
For purposes of quick identification, the voices have been grouped in a rough decimal order as follows:

SYNTH	STRINGS	BRASS	SYNTH	ORGAN/MONO
0 Synth Sweep w/ Glide	1 String 1	2 Brass 1	3 Vocal Chorus	4 Organ 1
10 Octave Trill	11 String 2	12 Brass 2	13 Tuned Percussion	14 Organ 2 (Pipes)
20 Sync Sample & Hold	21 String 3	22 Brass 3	23 Octave Synth	24 Organ 3
30 Poly Glide	31 String 4	32 Brass 4	33 Sizzle	34 Calliope
40 Sync Sweep 1	41 String 5	42 Brass 5	43 Sync 4	44 Organ 5
50 Wind Chimes	51 String 6	52 Brass 6	53 Double Reed	54 Mono 1
60 FM 1	61 String 7	62 Brass 7	63 Synth Organ	64 Mono 2
70 Bowed Octaves	71 String 8	72 Brass 8	73 Release Voice	74 Mono 3
80 Synth Woodwinds	81 String 9	82 Brass 9	83 Surprise	84 Mono 4
90 Quint Synth	91 String 10	92 Brass 10	93 Triangle Waves	94 Mono 5

EFFECTS	SYNTH	KB	SYNTH	KB
5 Filter Trill	6 Synth (Sq. Waves 1)	7 Electric Piano 1	8 Sync 1	9 Harp
15 Bells	16 Recorder	17 Power Synth	18 Sync 2	19 Steel Drums
25 Take-Off	26 Butterflies in Space	27 Clav 1	28 Sync 3	29 Clav 2
35 Log Drum	36 Flutes	37 Clav Wah	38 Unconditional Contour	39 Vibes
45 Sirens	46 Sync Sweep 2	47 Celeste	48 Sync Sweep 3	49 Harpsichord 1
55 UFO	56 Chorus Synth	57 Clav 3	58 Echo Whistle	59 Electric Piano 2
65 Sync Sweep 4	66 Square Waves 2	67 Quint Harpsichord	68 Wind Chimes 2	59 Electric Piano 3
75 Quint Filter Trill	76 Quint Oscillator Trill	77 Accordion	78 Synth Plectrum	79 Sync 5
85 Drop Off	86 Ring Mod	87 Harpsichord 2	88 Repeat Voice	89 Clav 4
95 Ring Mod 2	96 Dupe No. 75	97 Octave Synth 2	98 Synth Plectrum 2	99 Clav 5

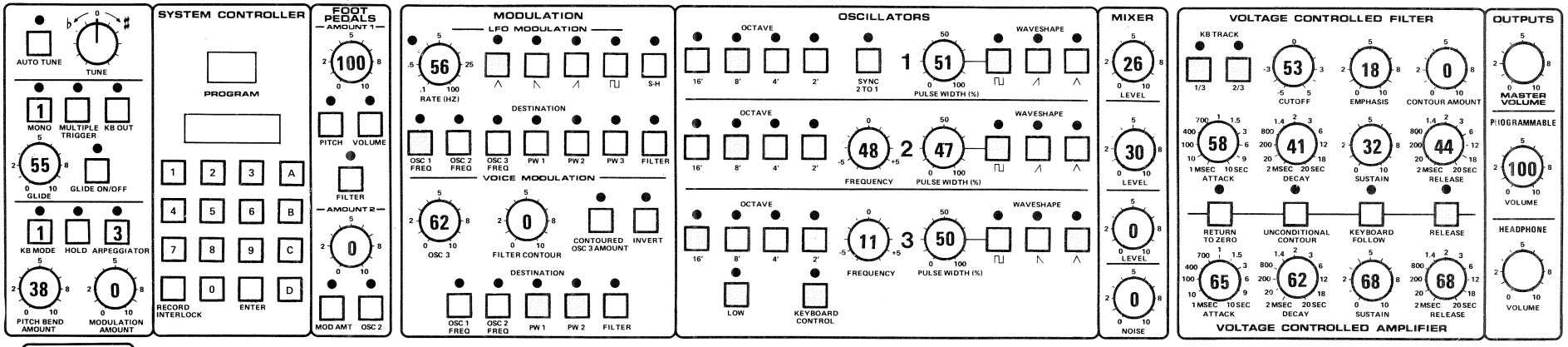
A conscious effort has been made to keep similar voices from being next to each other.

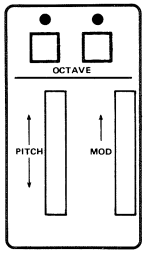




0. SYNTH (SWEEP WITH GLIDE)

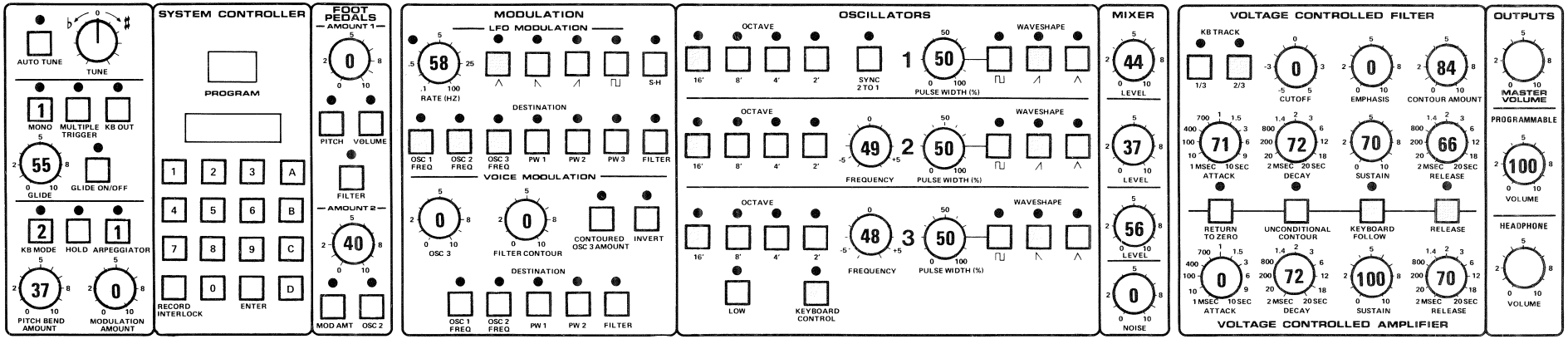
KB MODE 1 (cyclic) ensures that each new chord played will glide from somewhere else. Pedal 1 is programmed at 100; it can be used to control volume.

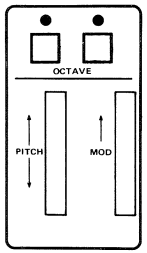




1. STRING 1

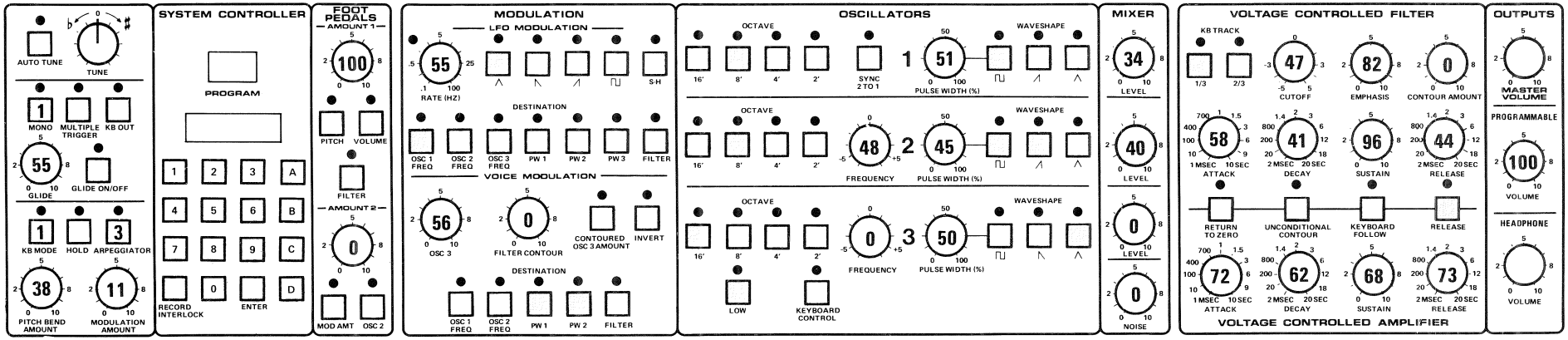
Advance the Modulation Wheel about halfway for broader vibrato effects. Pedal 1 can be used to control volume.

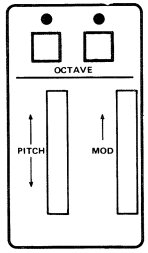




2. BRASS 1

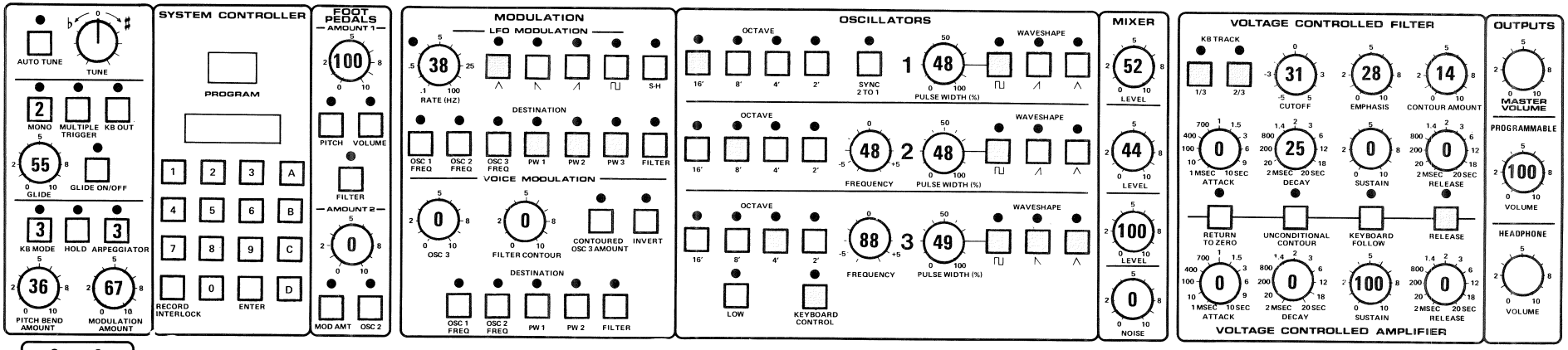
The Keyboard Follow function makes higher notes "snappier" than low notes. Turn on MOD AMT in the Pedal section for foot control of vibrato.

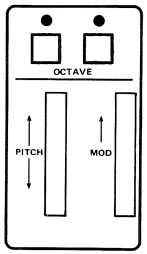




3. VOCAL CHORUS

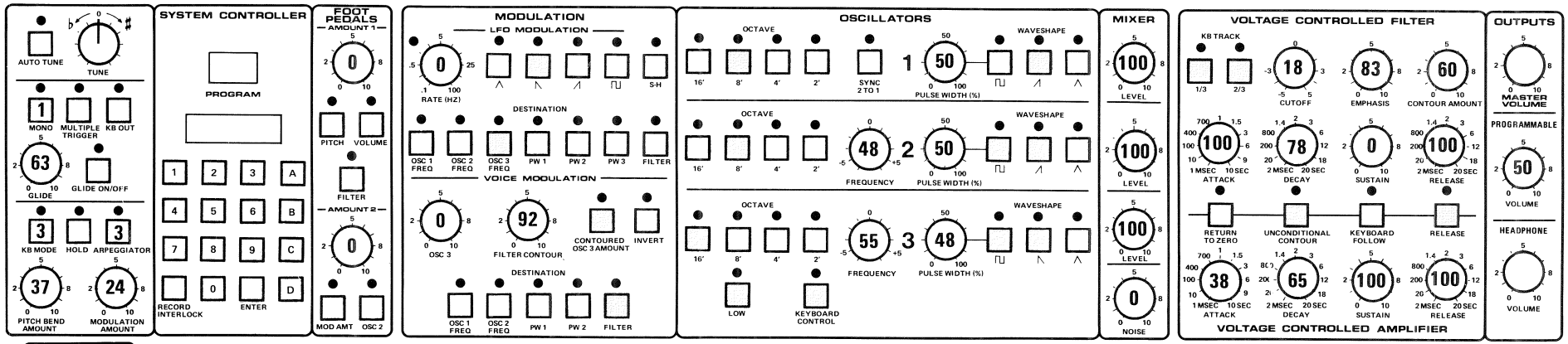
The high Emphasis setting produces a characteristic vocal resonance. Note: The character of this voice changes dramatically when the left-hand Octave controls are changed. Pedal 1 can control loudness.

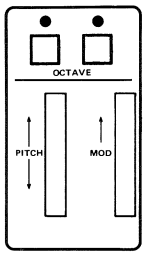




4. ORGAN 1

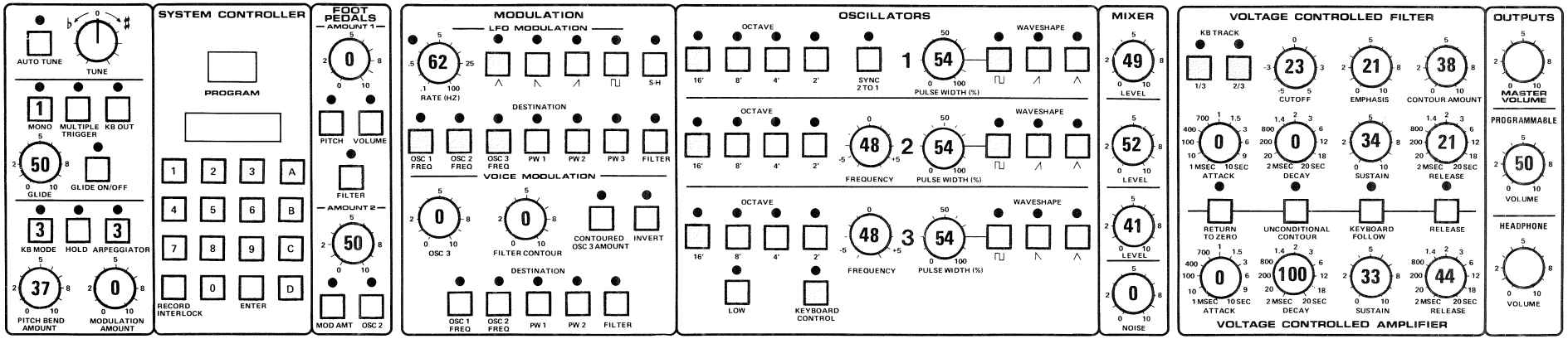
A high Level plus multiple waveshape outputs on Oscillator 3 add a little "dirt" to this sound. Pedal 1 can control loudness.

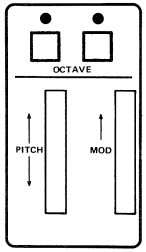




5. FX 1

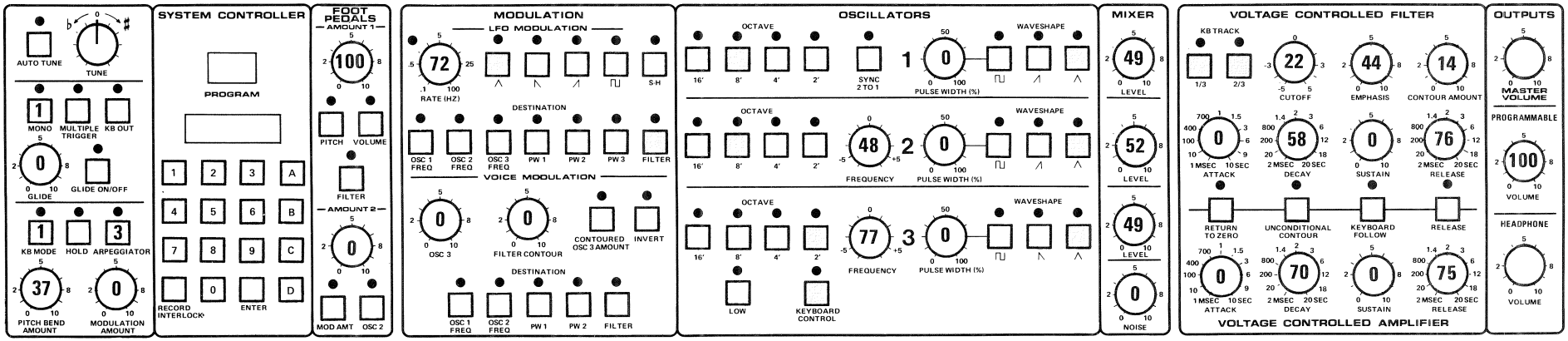
A contoured Osc 3 amount controls the Filter. Since Osc 3 is under keyboard control, the rate of the effect changes as a function of keyboard location.

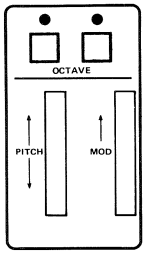




6. SYNTH (SQUARE WAVES)

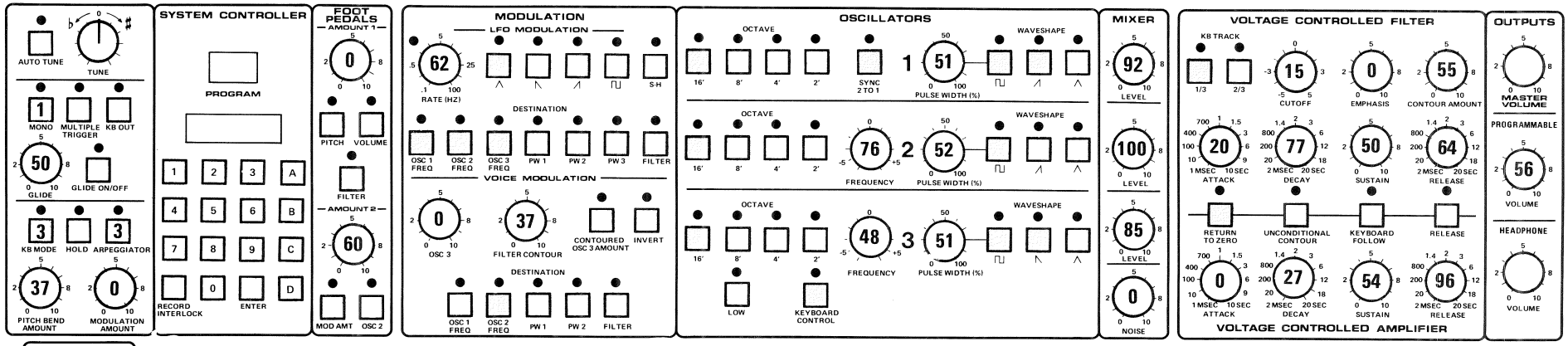
With the Filter attack and decay times at zero, each note has a "click" at the beginning. Pedal 2 can control modulation amount.

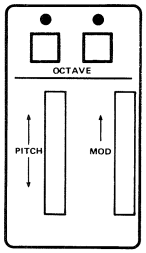




7. ELECTRIC PIANO 1

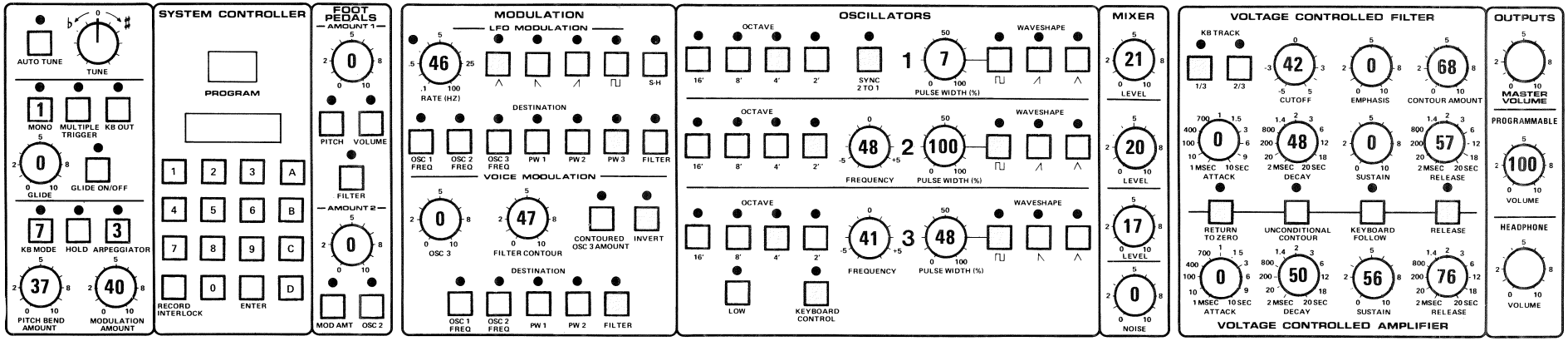
The overtone that creates the "tines" sound is produced by Osc 3. Pedal 1 can control volume.

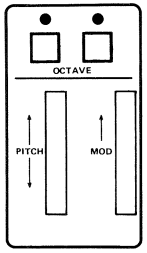




8. SYNTH (SYNC 1)

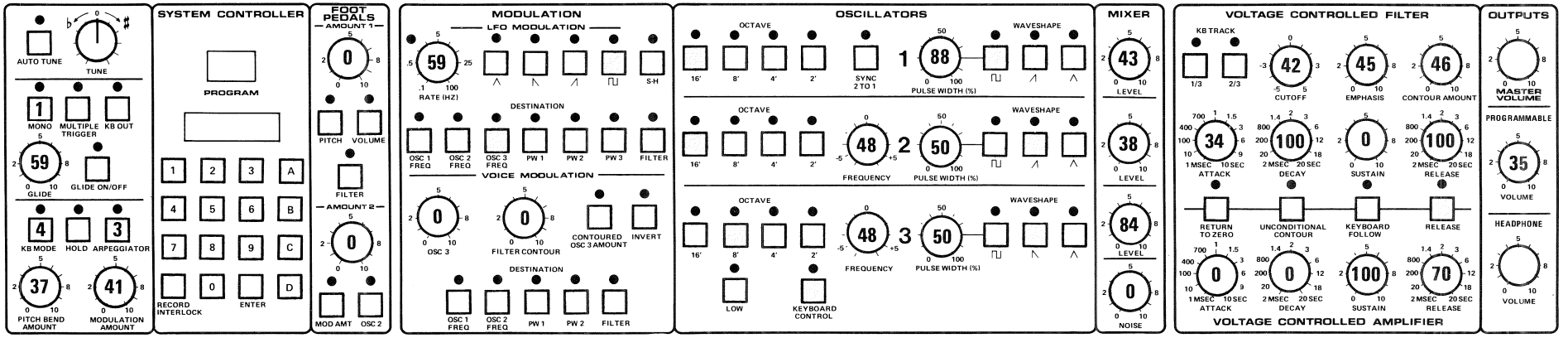
Any attempt to change the frequency of Osc 2 produces the "sync" effect. The Program routes the Filter Contour to Osc 2; manual changes can be made with Pedal 2.

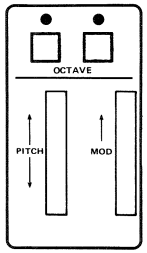




9. HARP

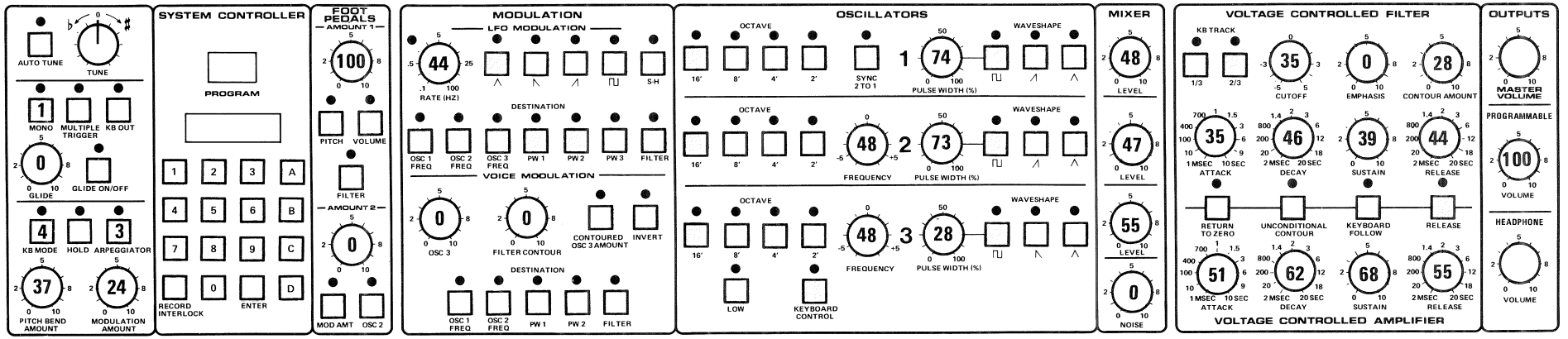
Narrow pulse waves produce the plucked-string effect. A characteristic playing style is arpeggiated or rolled chords.

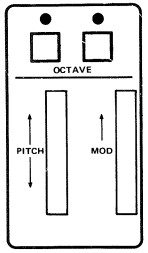




10. SYNTH (OCTAVE TRILL)

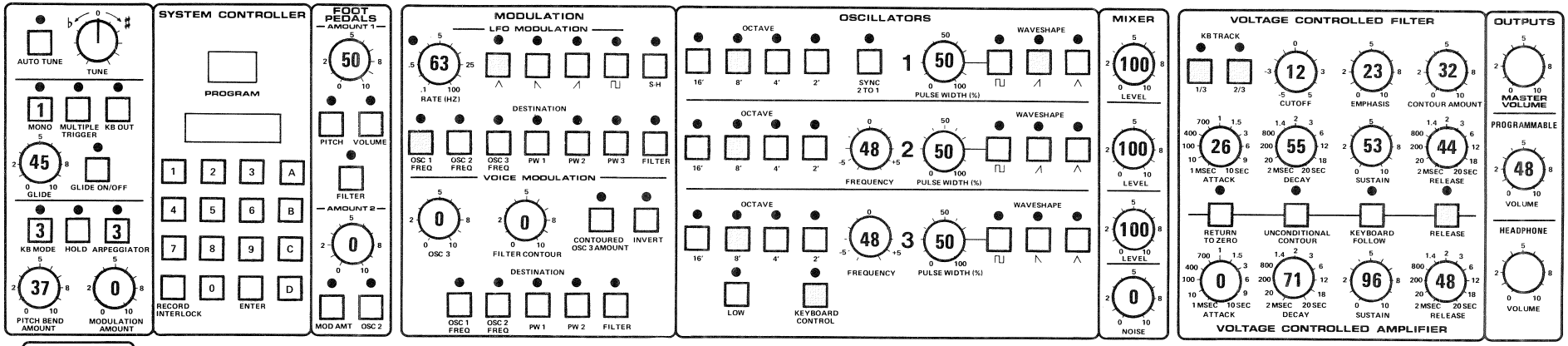
The LFO modulates all six voices at the same rate. If the trill is not exactly an octave, adjust the Modulation Amount





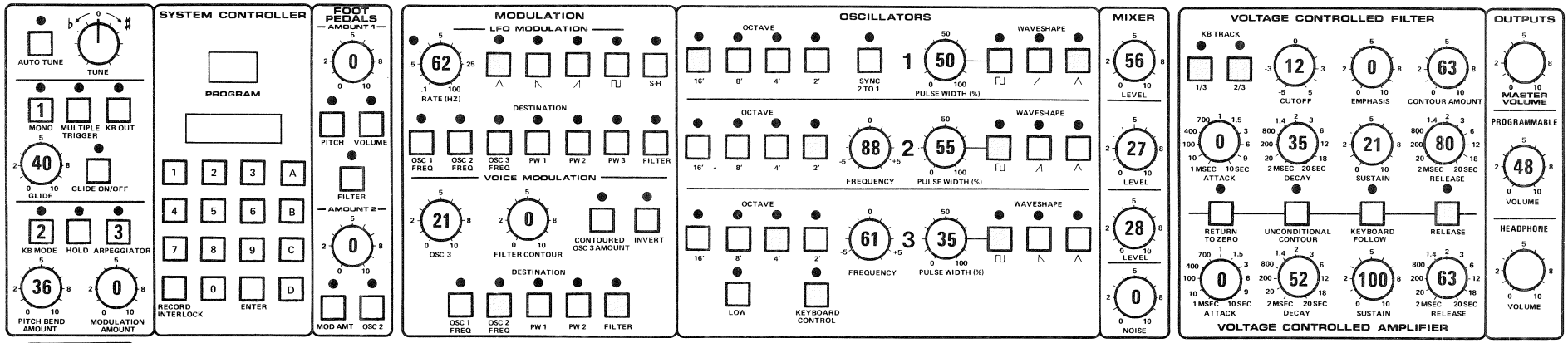
11. STRING 2

Setting the VCA attack time slower than the Filter produces a "bowing" effect. Pedal 1 can control volume.



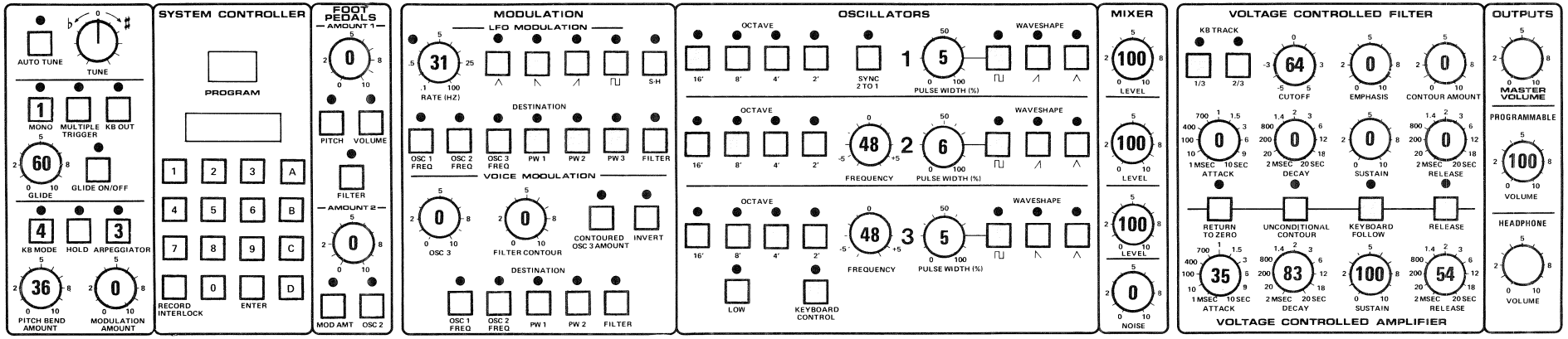
12. BRASS 2

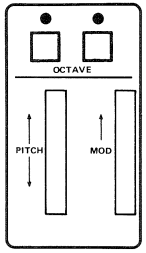
For a chorus brass sound, turn on the sawtooth waveshape for Osc 2 and/or Osc 3. Pedal 1 can control filter cutoff (brightness).



13. FX (PERCUSSION)

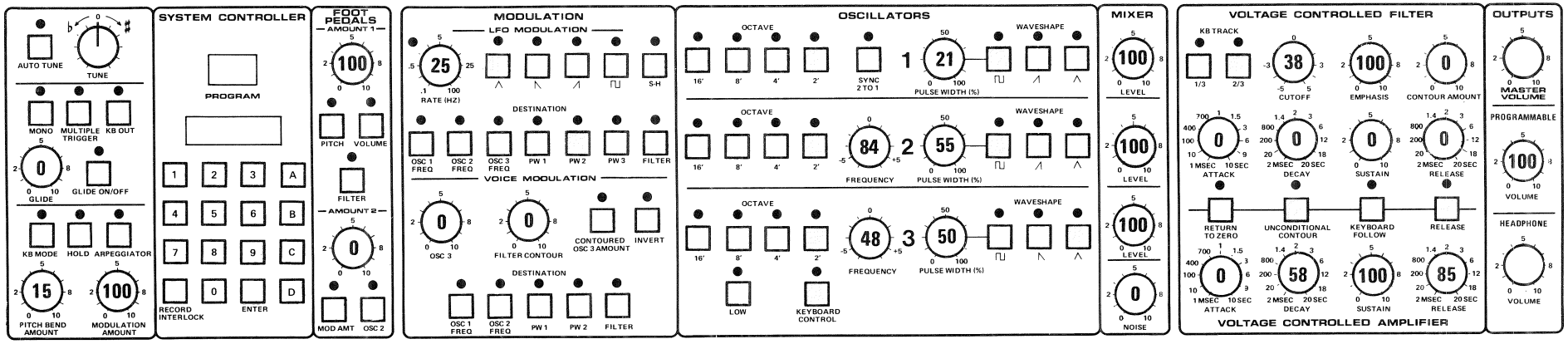
"Tapping" a key and releasing it immediately lets the percussive effect ring longer; holding a key down damps the effect.

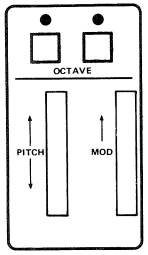




14. ORGAN 2 (PIPES)

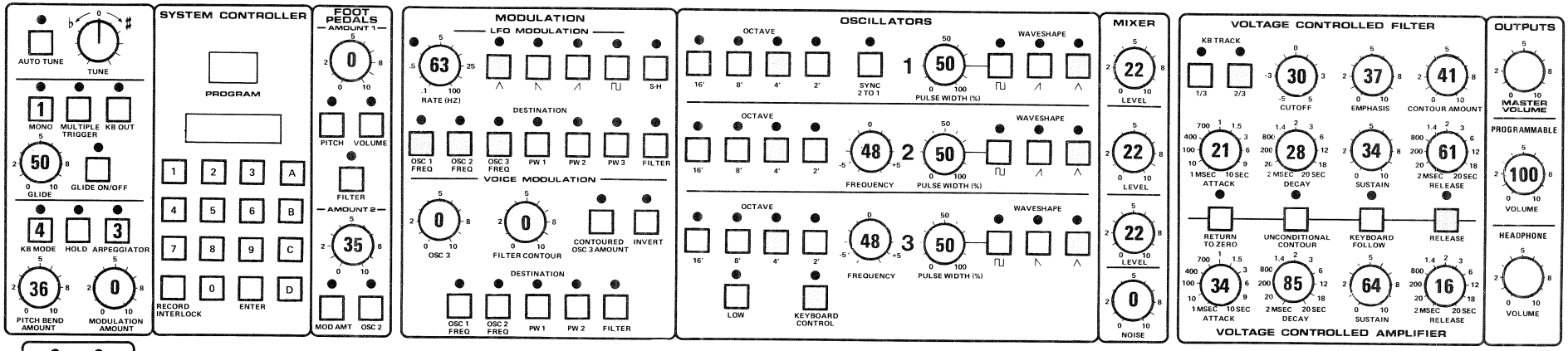
The key to this voice is pitching the oscillators at different octaves to simulate the different ranks of a pipe organ.

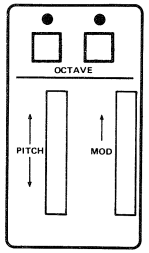




15. BELLS

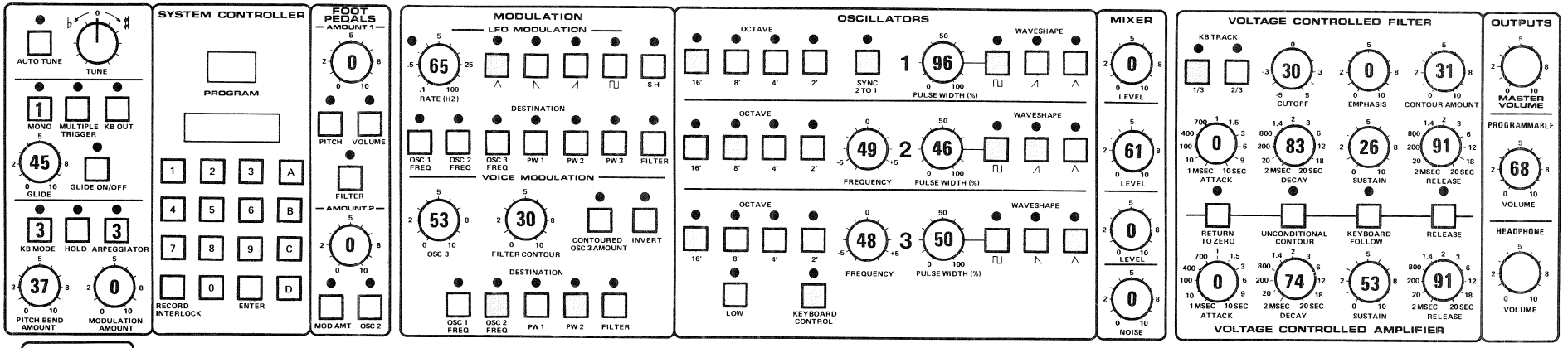
Pitches produced by this voice intentionally do not match the key played.
Pedal 1 can control volume.

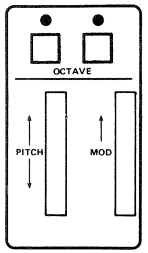




16. RECORDER

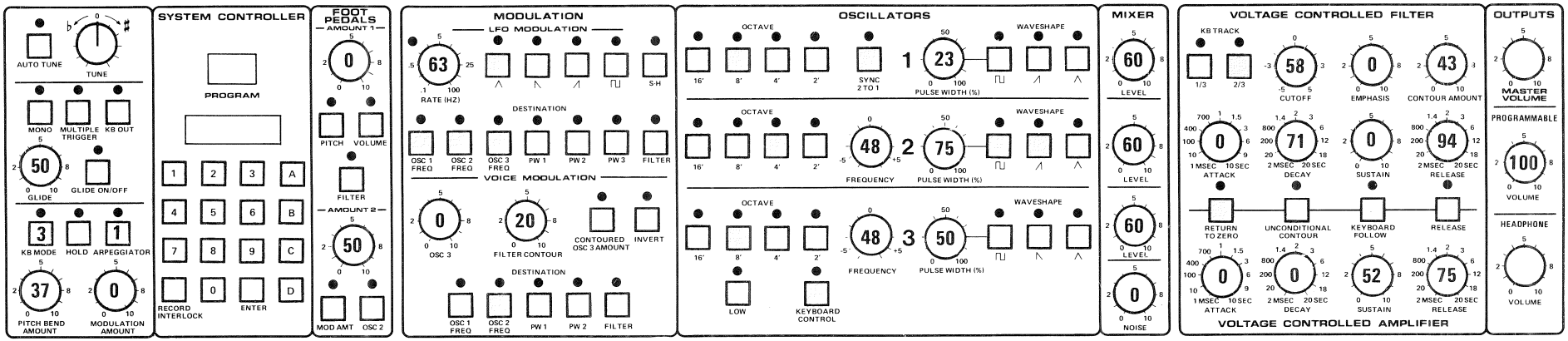
Vibrato can be introduced with the Mod Wheel or Pedal 2.

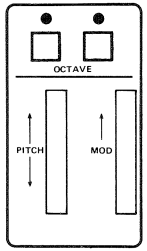




17. POWER SYNTH

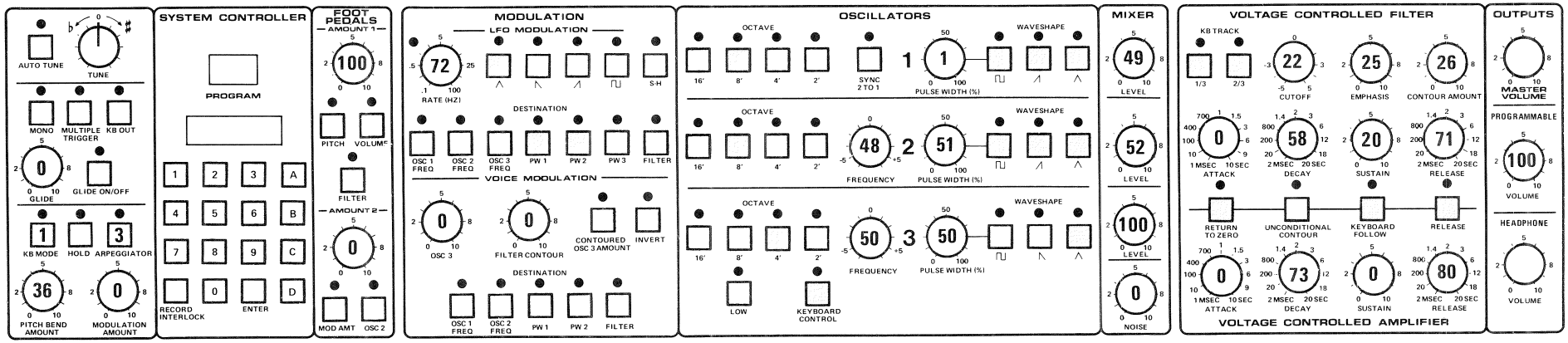
This voice is especially powerful in the lower register. Try turning on the GLIDE ON/OFF switch.

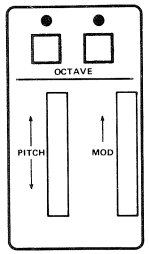




18. SYNC 2

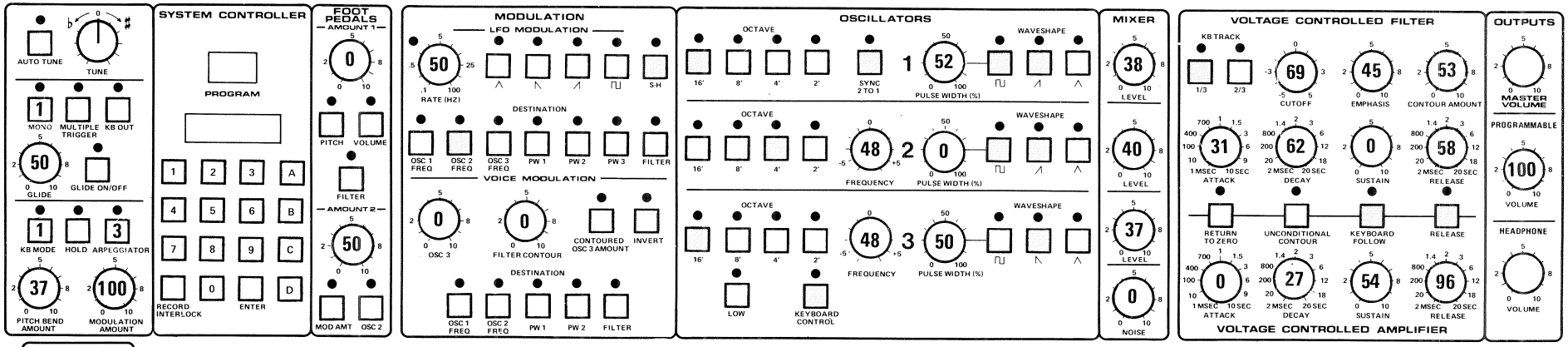
This voice produces an octave overtone effect on sustained tones. Pedal 2 can produce additional sync effects.





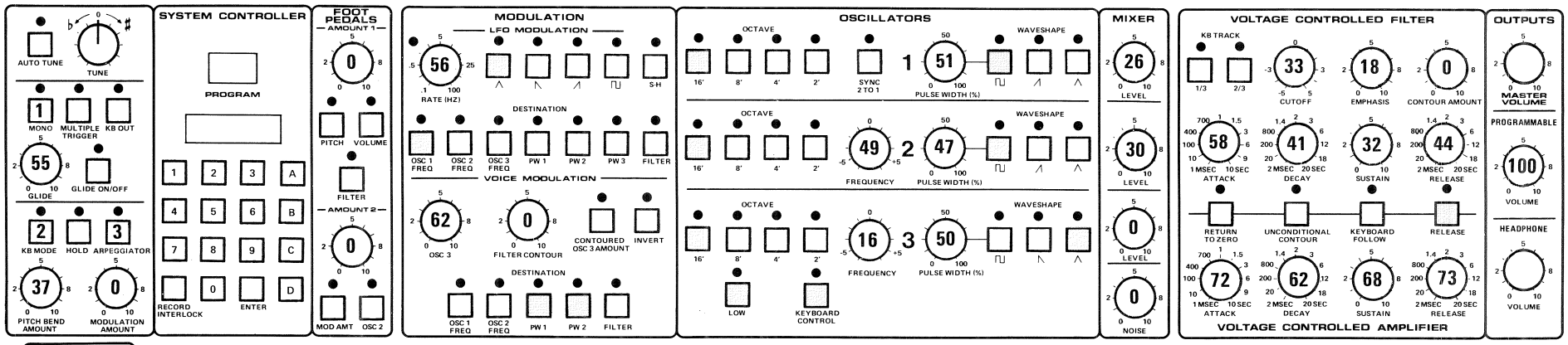
19. STEEL DRUMS

The key to this voice is the detuning of Osc 3. It can be tweaked in or out of tune to fit individual taste.



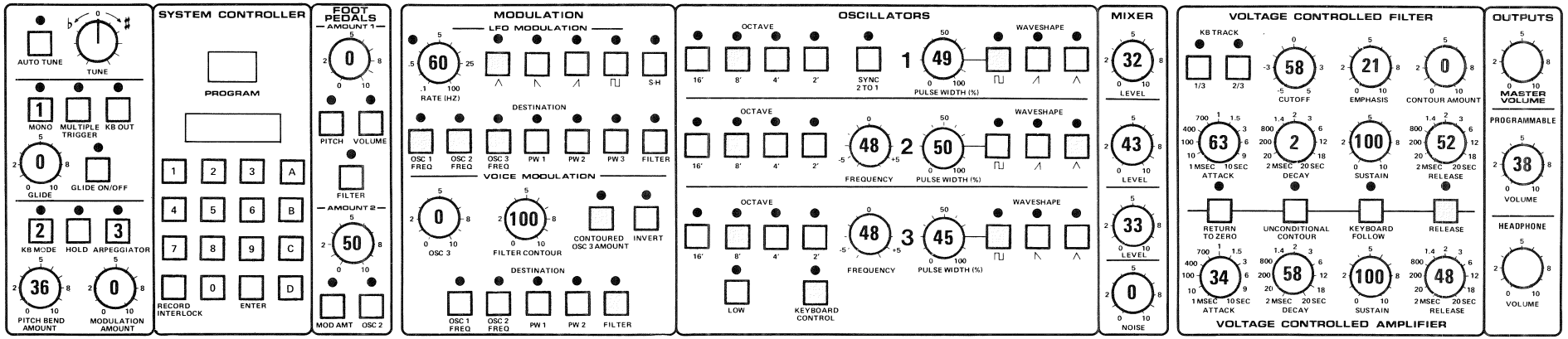
20. SYNC SAMPLE AND HOLD

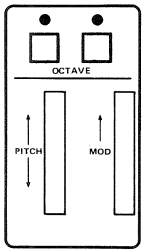
The Sample and Hold voltage is sent to the synced Osc 2. Try this voice with Glide and with additional sync effects from Pedal 2.



21. STRING 3

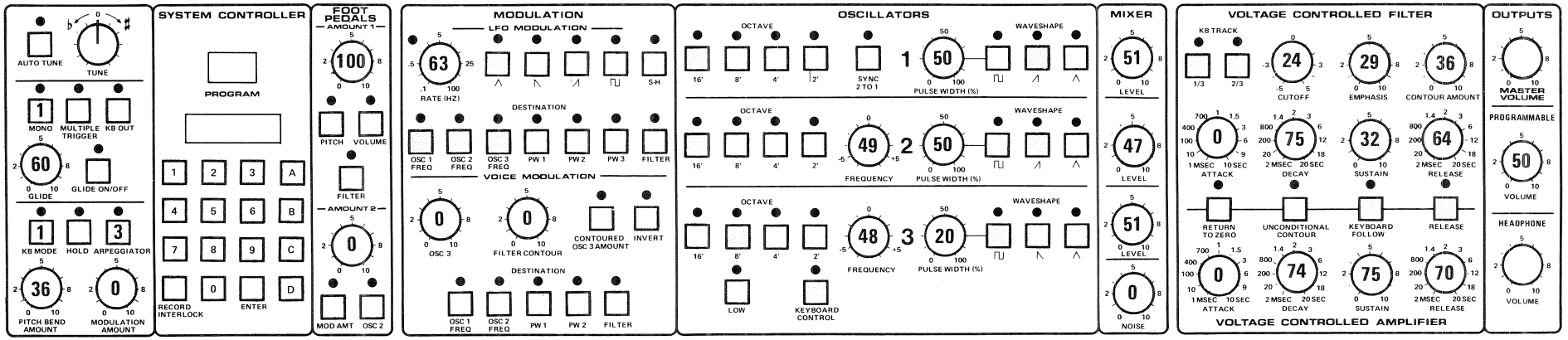
Long attack times and heavy modulation make this voice useful for chord background work. For more vibrato, advance the MOD WHEEL to about 1/2.

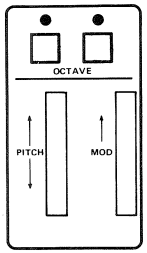




22. BRASS 3

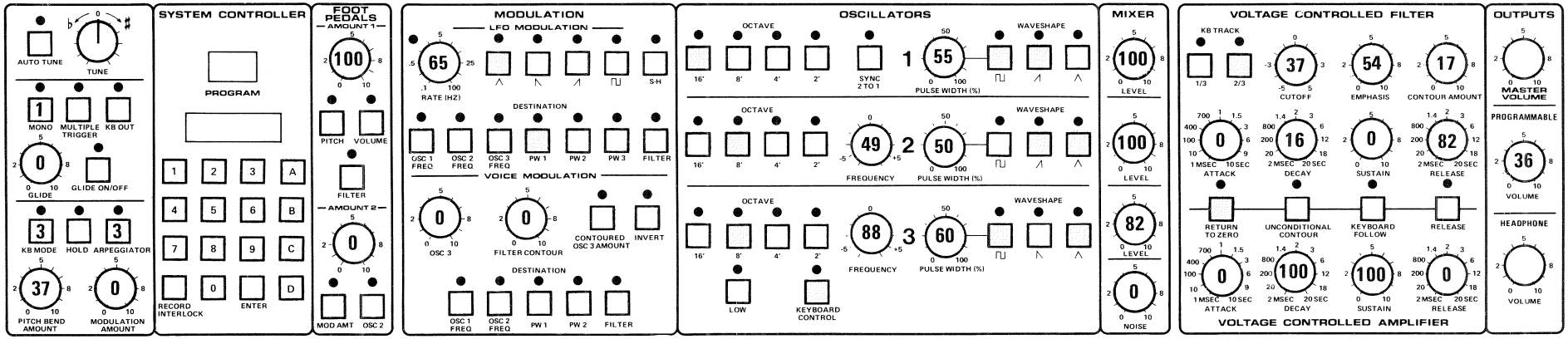
The "brassiness" of this voice is generated in the voice modulation section. Pedal 2 can control vibrato.

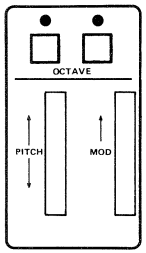




23. OCTAVE SYNTH

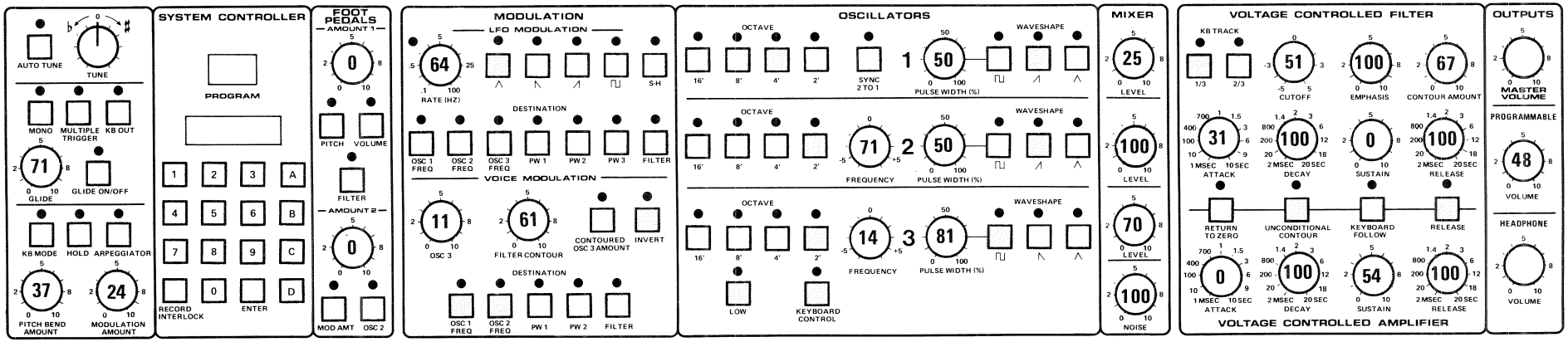
Try this voice with and without Glide. Pedal 1 can control Filter Cutoff (brightness).

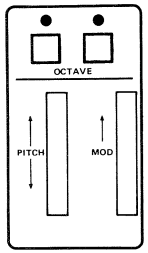




24. ORGAN 3

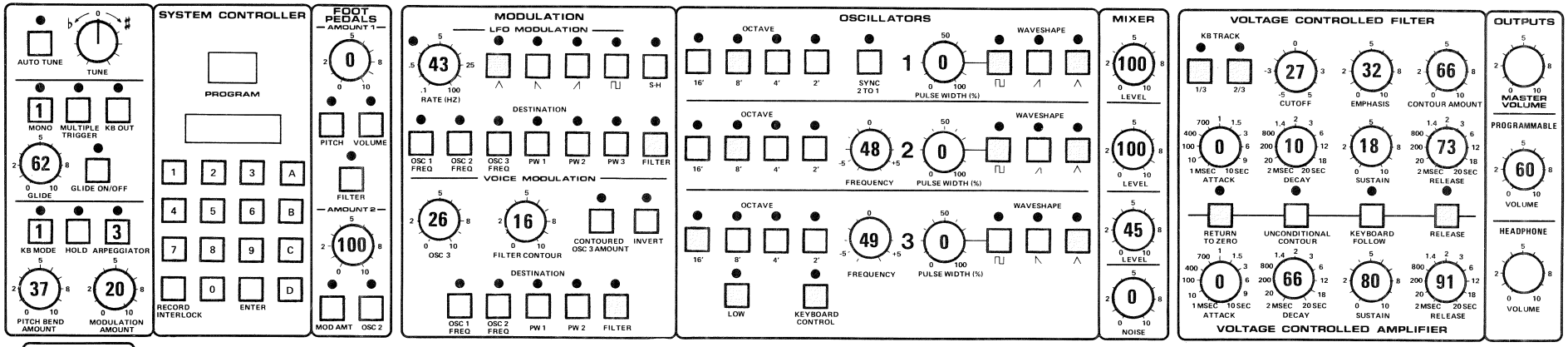
For more animation to the sound, move the MOD WHEEL up to about 1/2.
Pedal 1 can control volume.





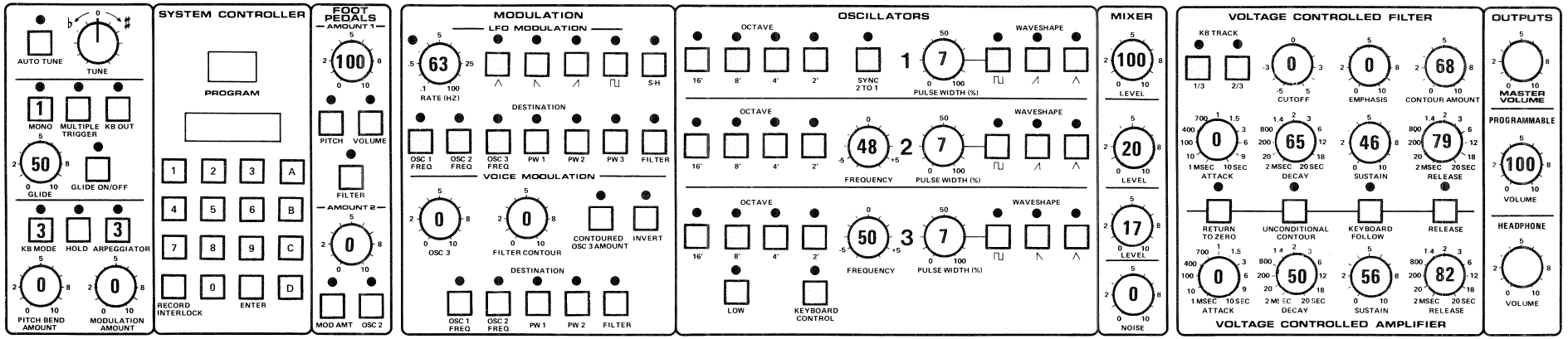
25. TAKE-OFF

The amount of pitch rise is determined by how long a key is held down.
Try turning on different destinations in the LFO Modulation section.



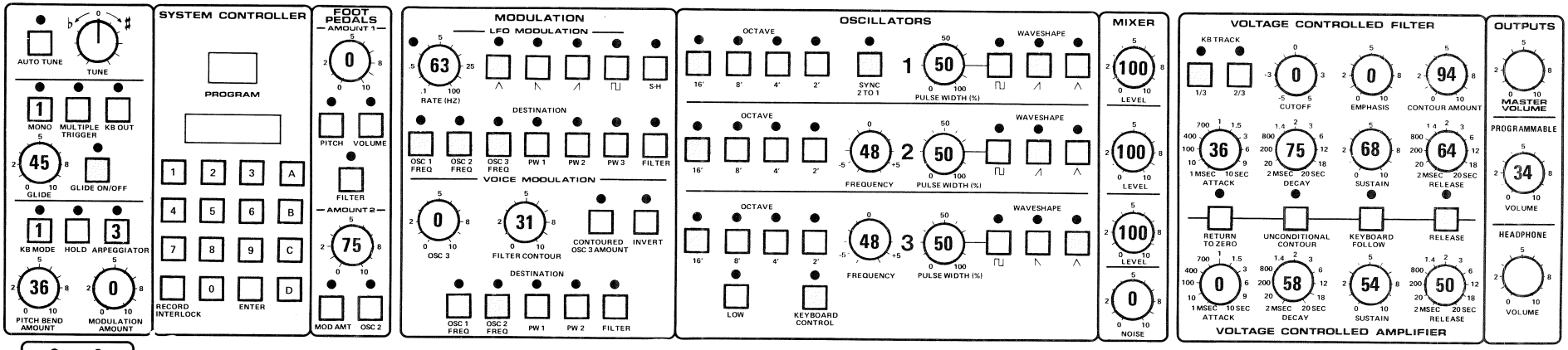
26. BUTTERFLIES IN SPACE

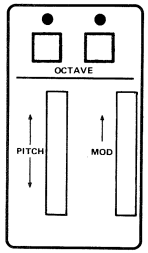
The Filter "flutter" rates will be slightly different for each voice.
For a more unified effect, turn up the MOD WHEEL.



27. CLAV 1

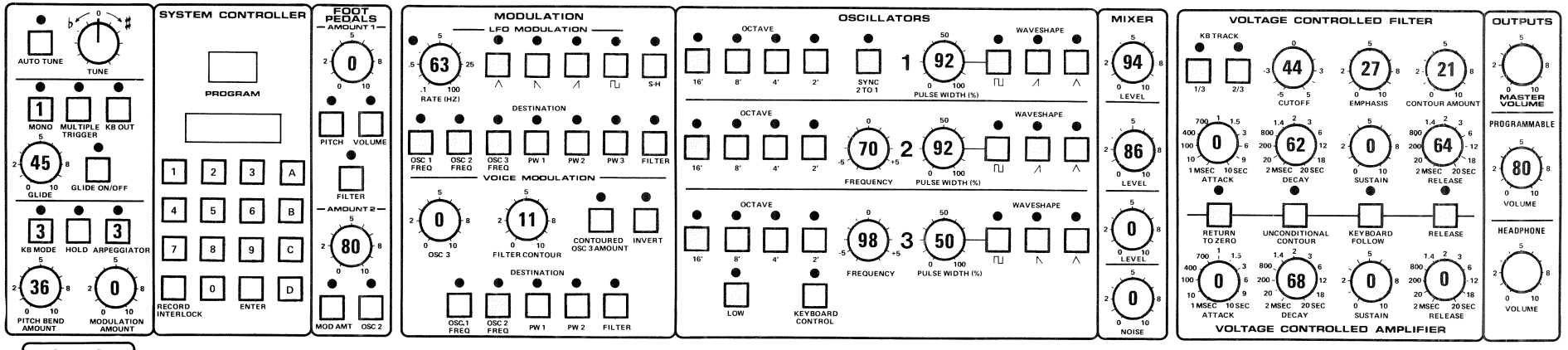
For a chorus clav sound, turn on the pulse waveshapes for Osc 2 or Osc 3.
Pedal 1 can control brightness; the Mod Wheel brings in vibrato.

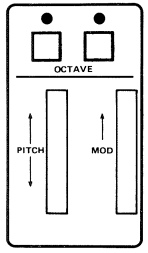




28. SYNC 3

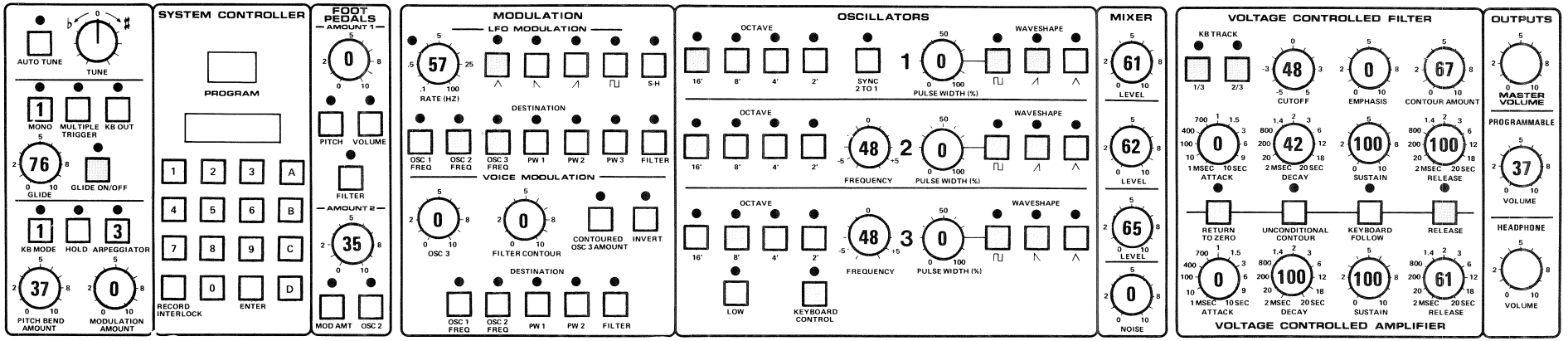
Pedal 2 can control additional sync effects; the Mod Wheel will introduce vibrato.

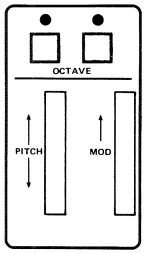




29. CLAV 2

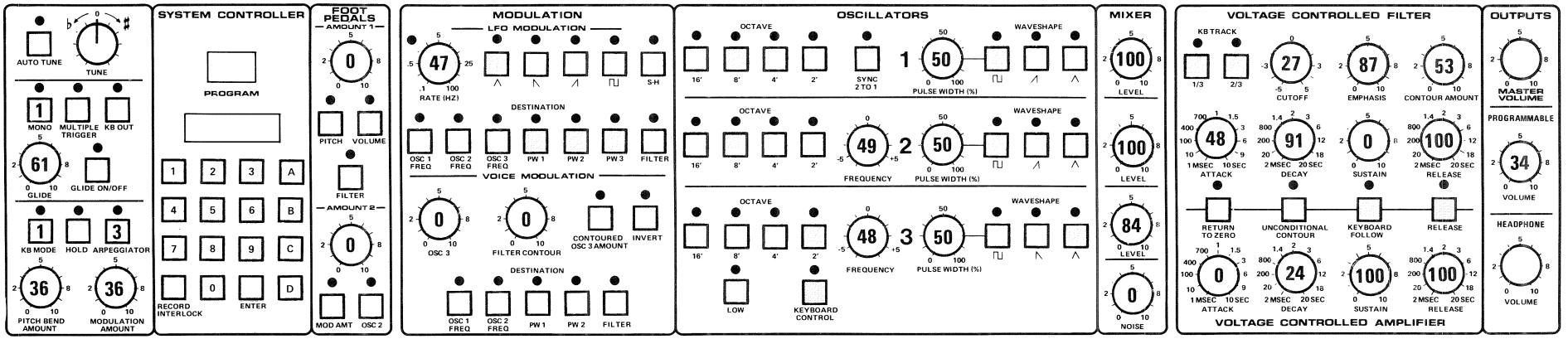
Pedal 2 can control additional sync effects; the Mod Wheel will introduce vibrato.

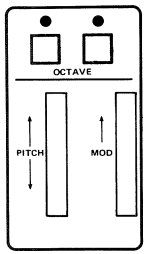




30. POLY GLIDE

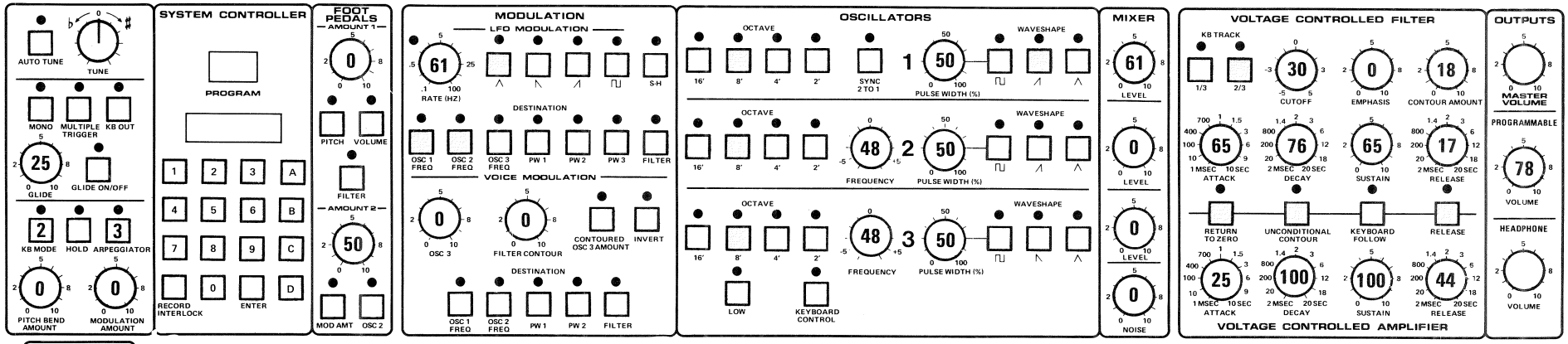
Modulation can be introduced from the Mod Wheel and/or Pedal. Note that Osc 1 is not modulated. With small amounts of modulation, this produces a chorus effect.

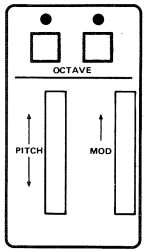




31. STRING 4

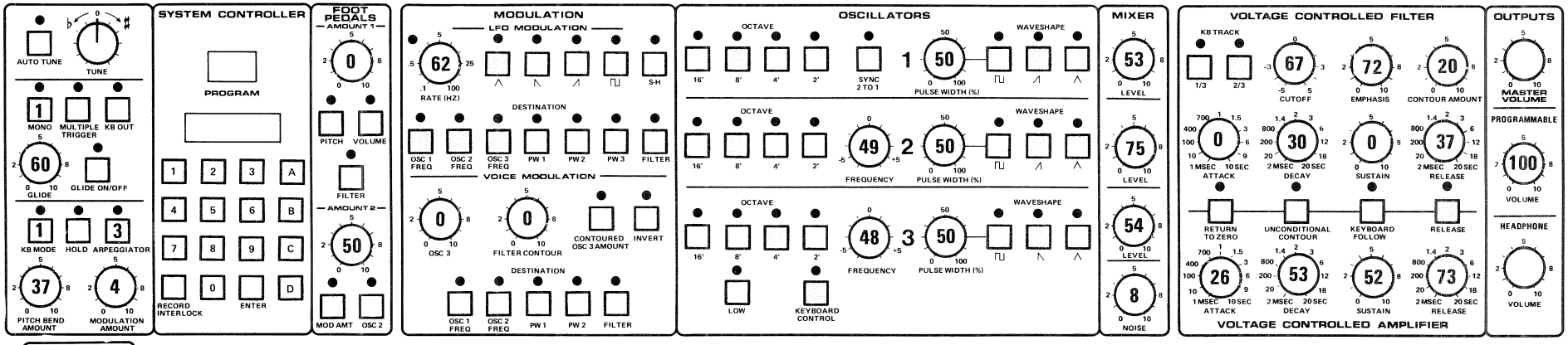
This is a synth string voice; try it with and without Glide, and with varying amounts of modulation.

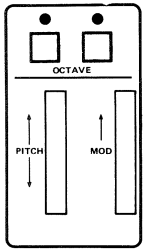




32. BRASS 4

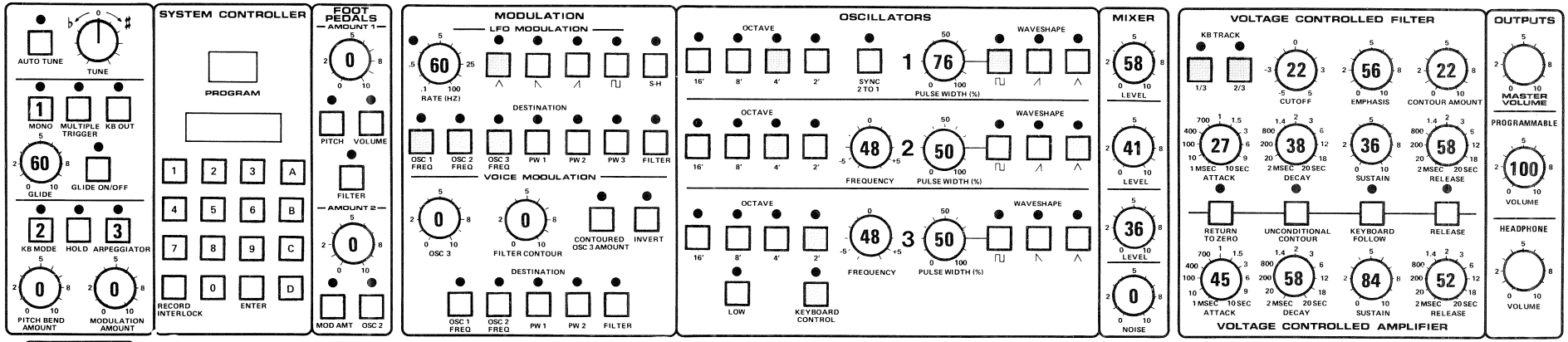
This is a very subtle voice; modulation (from the Mod Wheel and/or Pedal 2) should be used sparingly.

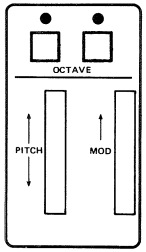




33. SIZZLE

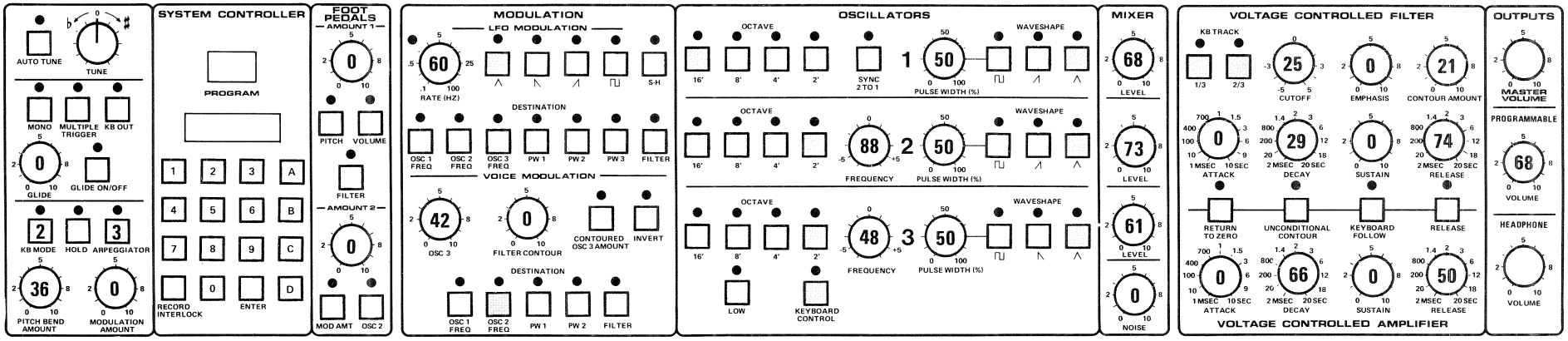
Modulation can be introduced from the Mod Wheel and/or Pedal 2.

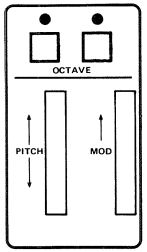




34. CALLIOPE

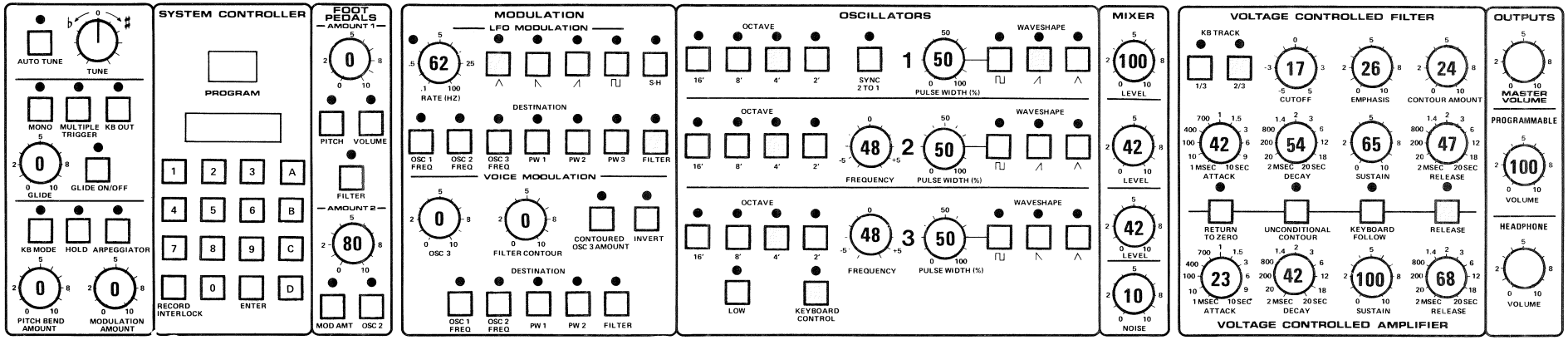
For a slightly brighter sound, turn on any of the waveshapes for Osc 3.

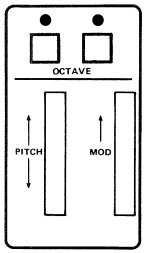




35. LOG DRUM

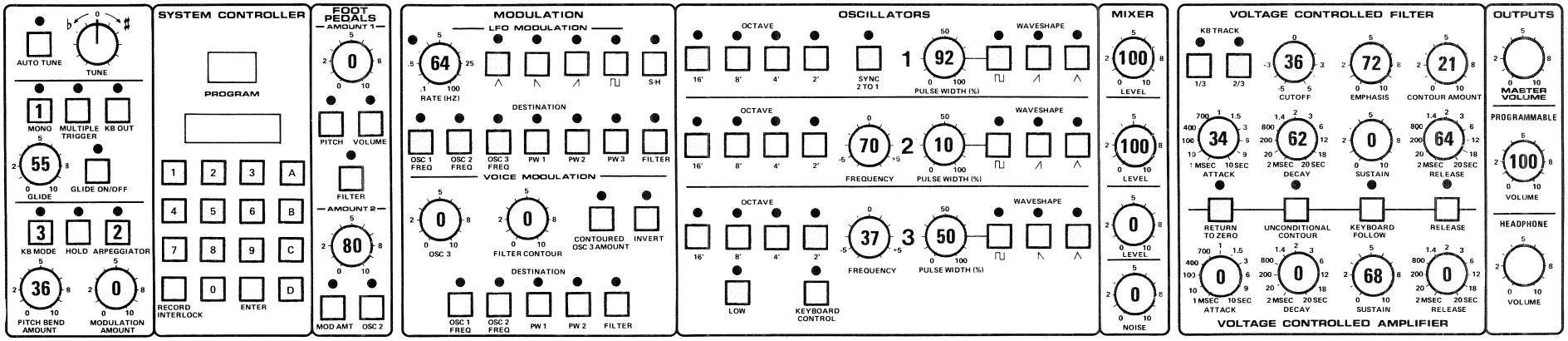
Try this voice with the Arpeggiator turned on; experiment with different LFO rates.

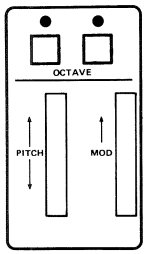




36. FLUTES

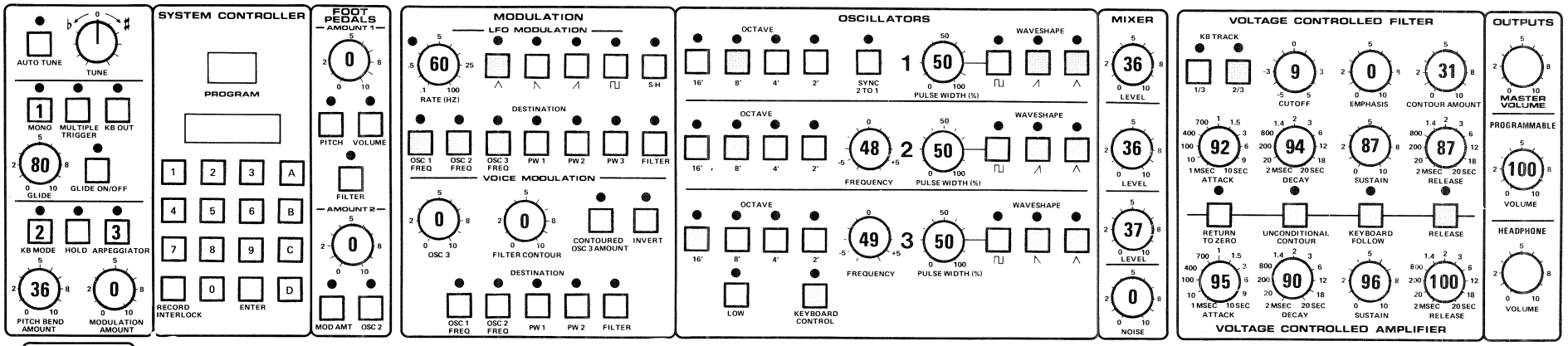
For a chorus flute sound, turn on the sawtooth waveshapes for Osc 2 or Osc 3. The small amount of noise simulates the air moving through the flute. Modulation is available from the Mod Wheel and/or Pedal 2.





37. CLAV WAH

Vibrato is available at the Mod Wheel; Pedal 2 will control sync effects.

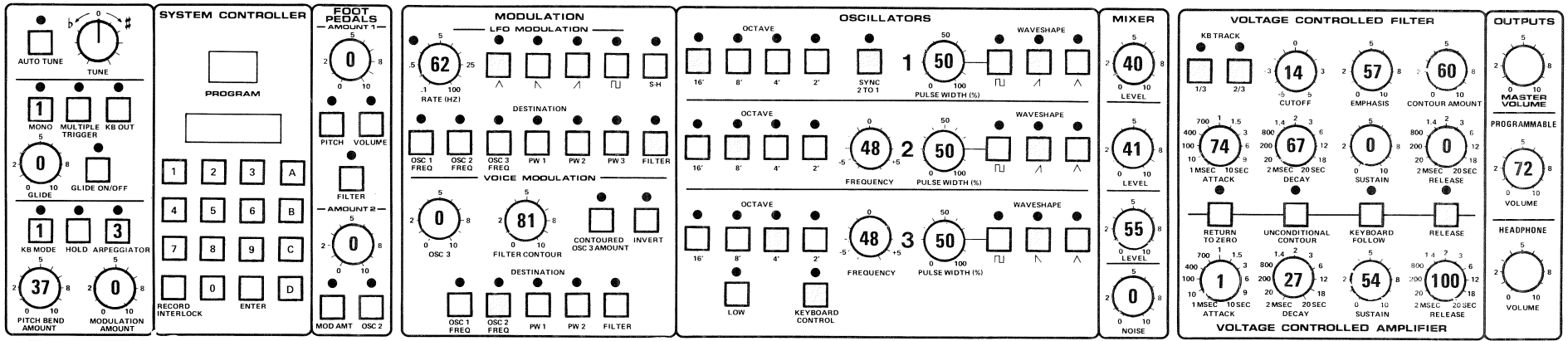


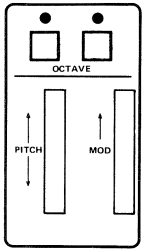
38. UNCONDITIONAL CONTOUR

The Unconditional Contour completes a note's cycle whether or not the key is held down; the Keyboard Follow makes that cycle shorter toward the top of the keyboard.

39. VIBES

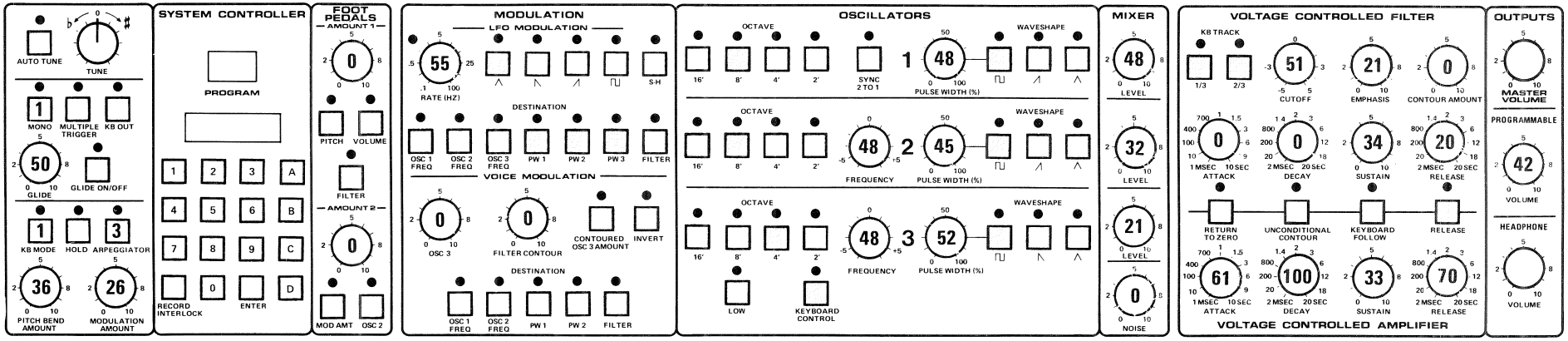
For more tremolo effect, move the Mod Wheel up to approximately 3/8 to 1/2.

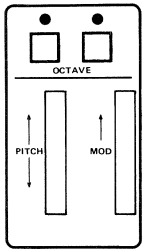




40. SYNC SWEEP

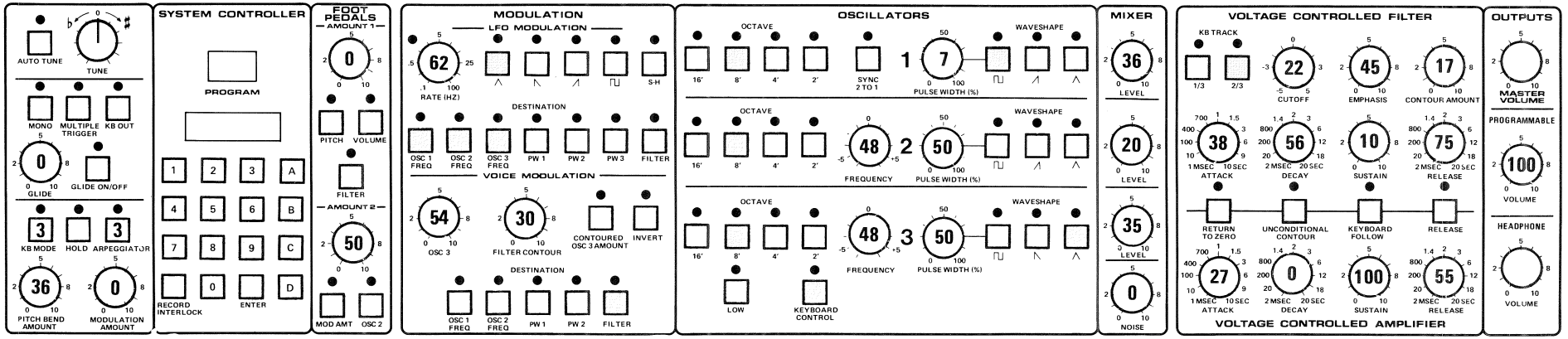
Turning up the Mod Wheel adds a tremolo effect.





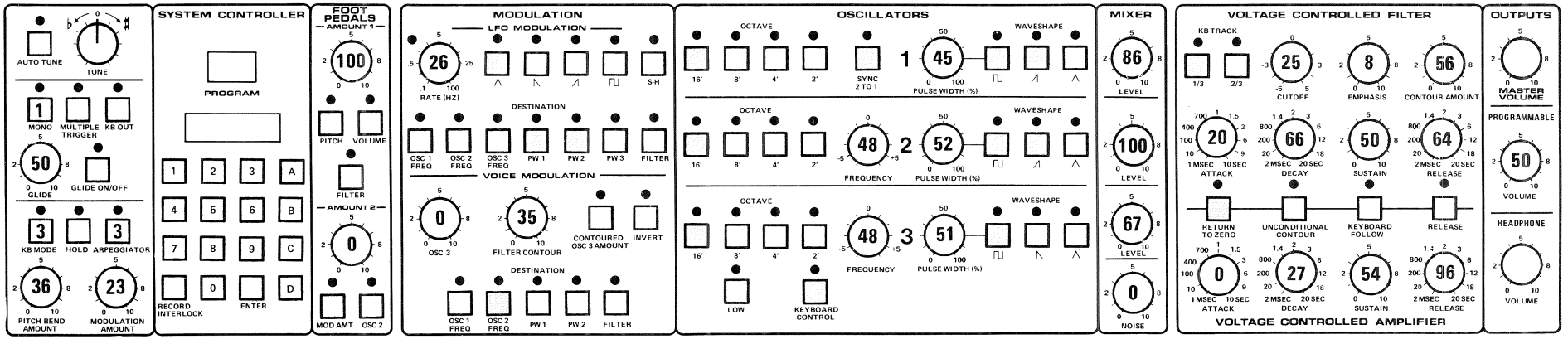
41. STRING 5

To add more animation to the sound, turn up the Mod Wheel (or the Modulation Amount control).



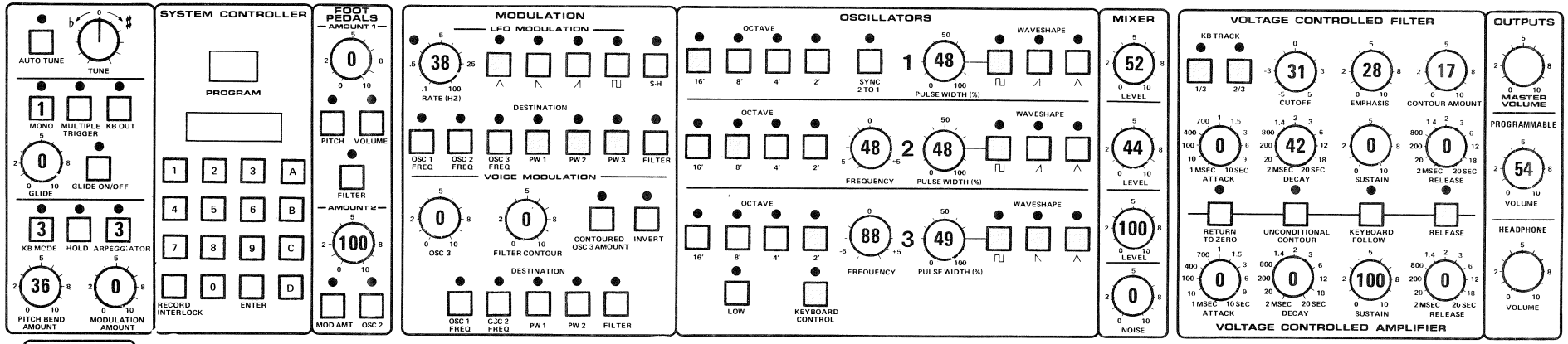
42. BRASS 5

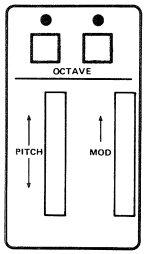
The "splat" of the attack is produced in the Voice Modulation section. Pedal 2 can control vibrato.



43. SYNC 4

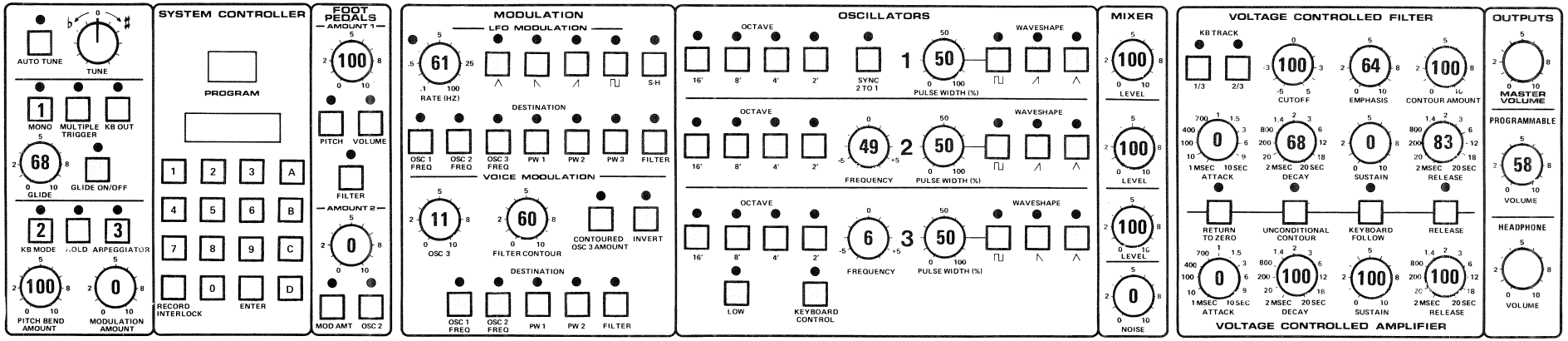
Pedal 1 can control brightness; the Mod Wheel will introduce vibrato.

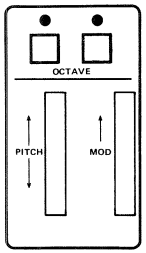




44. ORGAN 5

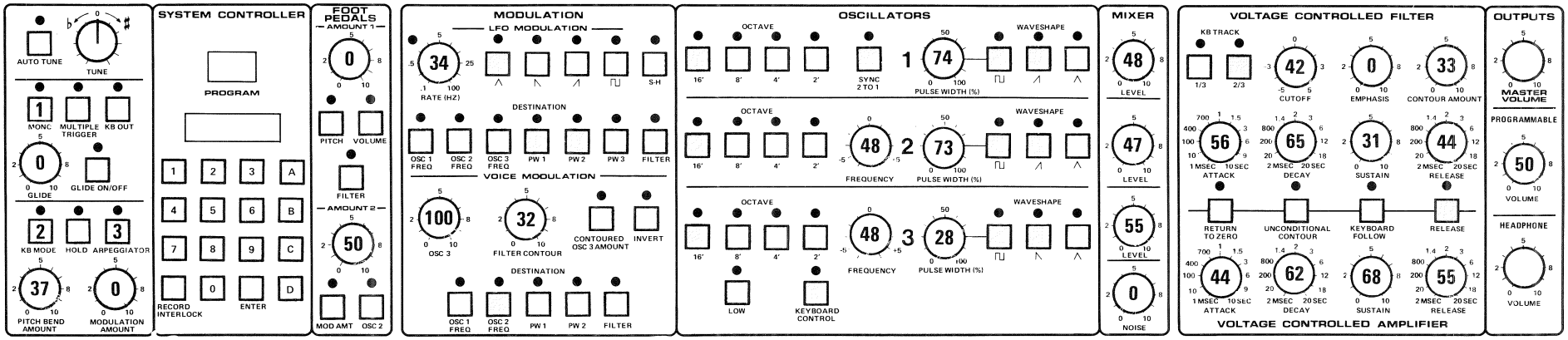
The amount of percussion effect can be controlled with the Osc 3 Level control; Pedal 2 (or the Mod Wheel) will introduce a "rotating speaker" effect.

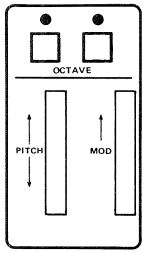




45. SIRENS

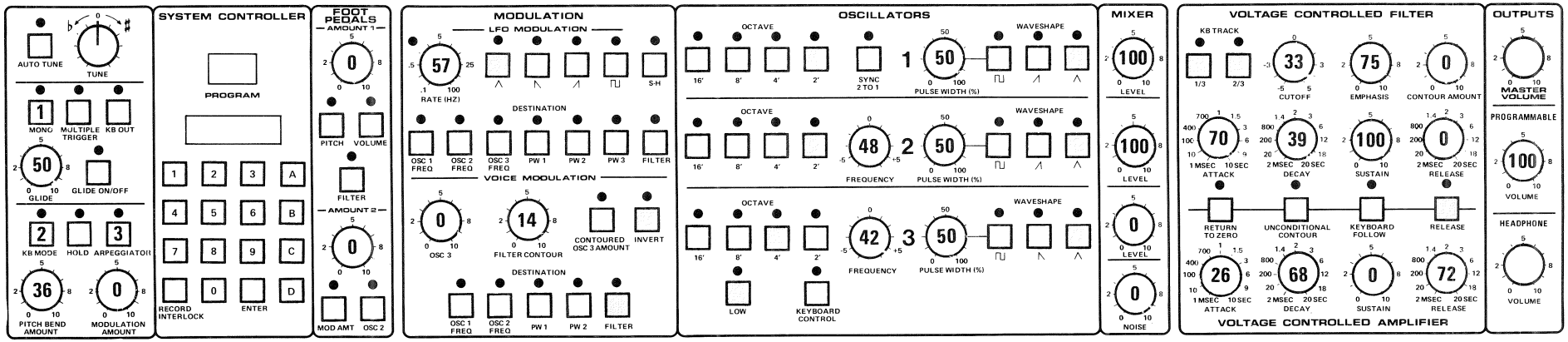
The speed of the "pulsing" effect is dependent on keyboard location; high notes pulse faster than low notes.

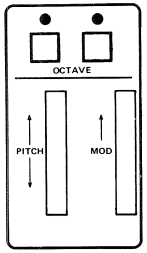




46. SYNC SWEEP 2

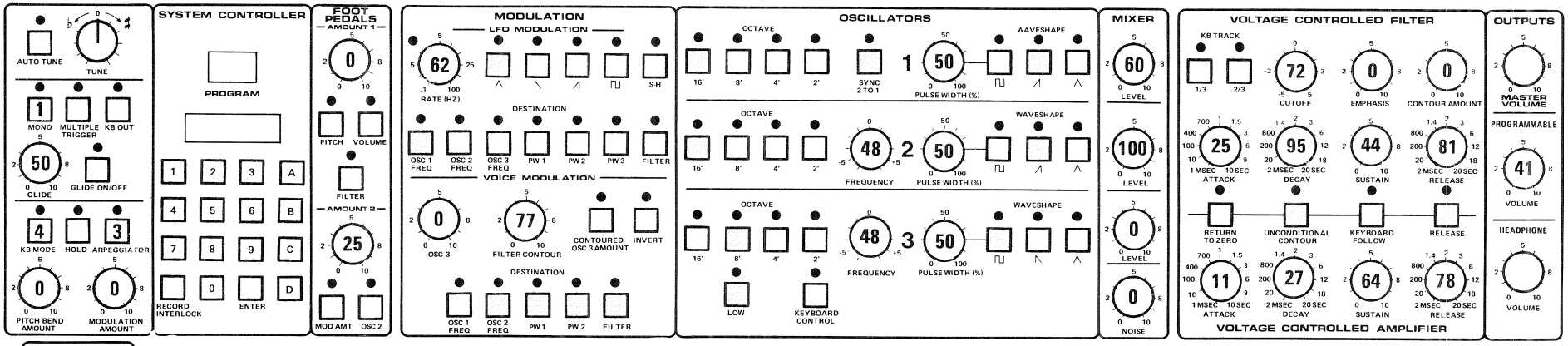
Pedal 2 (or the Mod Wheel) will add more animation to the sound.

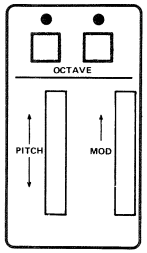




47. CELESTE

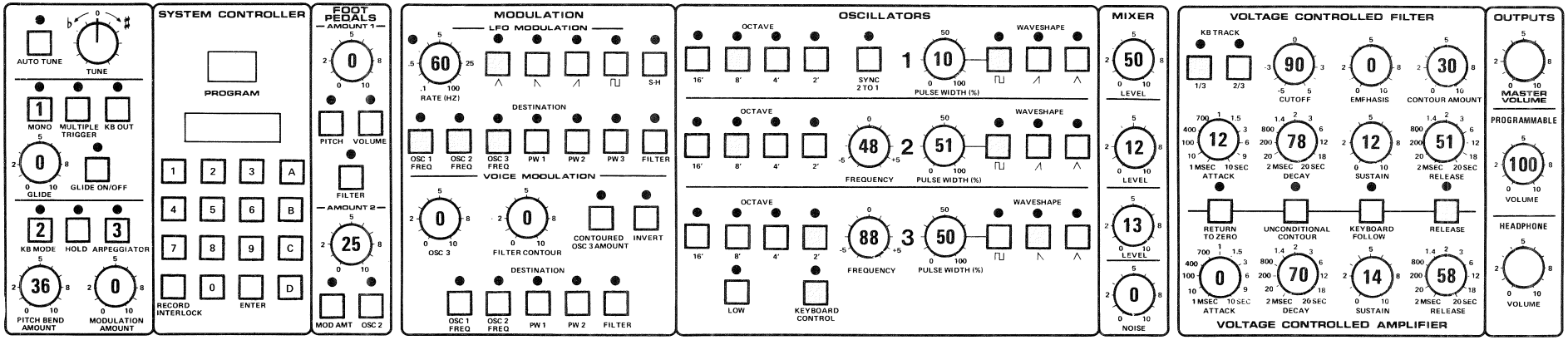
The character of this voice will change dramatically if the left-hand Octave controls are changed to - 1.

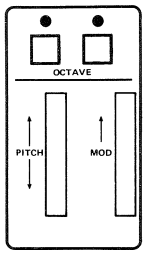




48. SYNC SWEEP 3

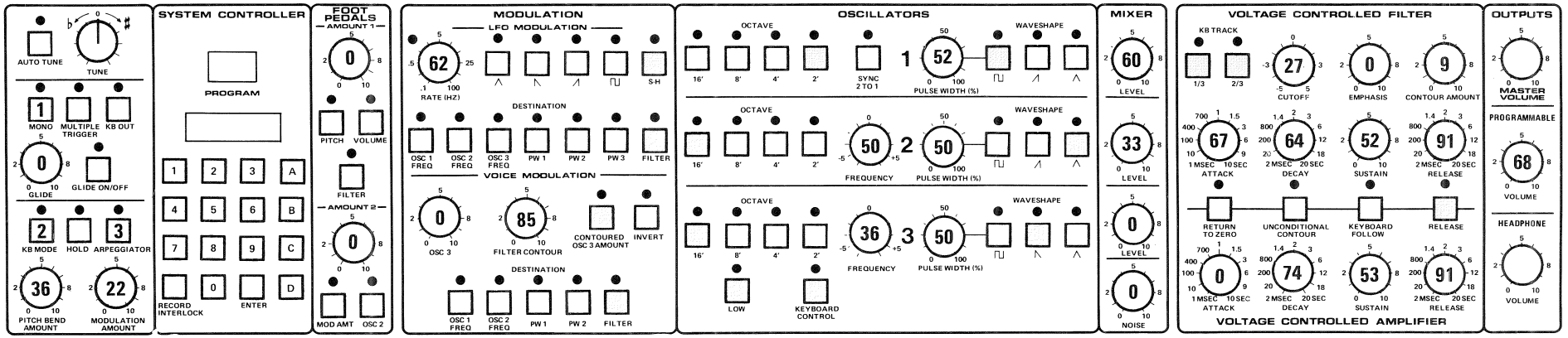
The sync sweep effect is slow while keys are held down and accelerates when the key is released.

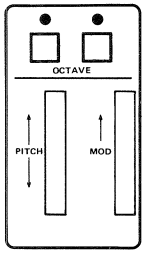




49. HARPSICHORD 1

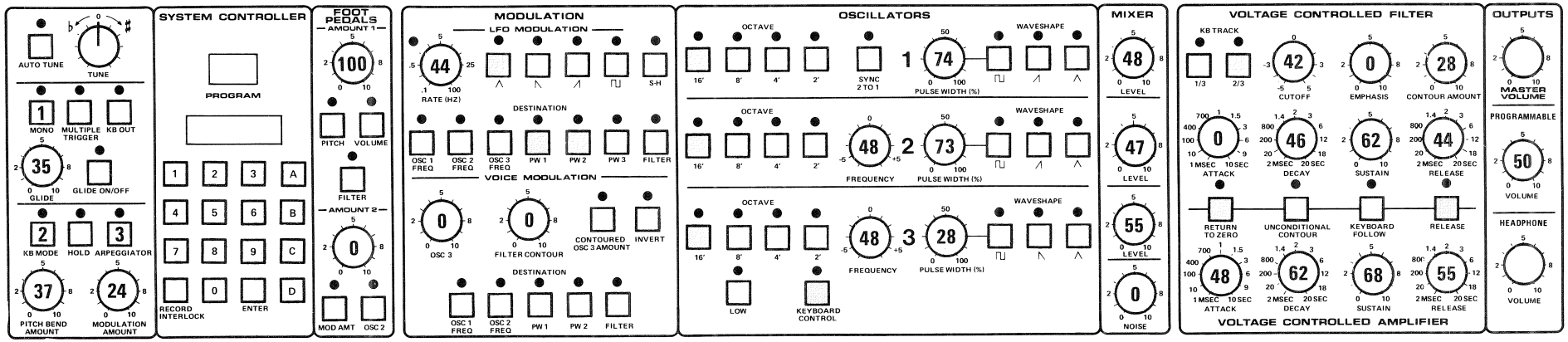
Modulation can be introduced from Pedal 2 and/or the Mod Wheel.

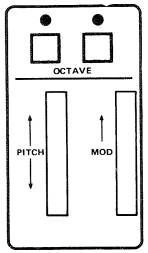




50. WIND CHIMES

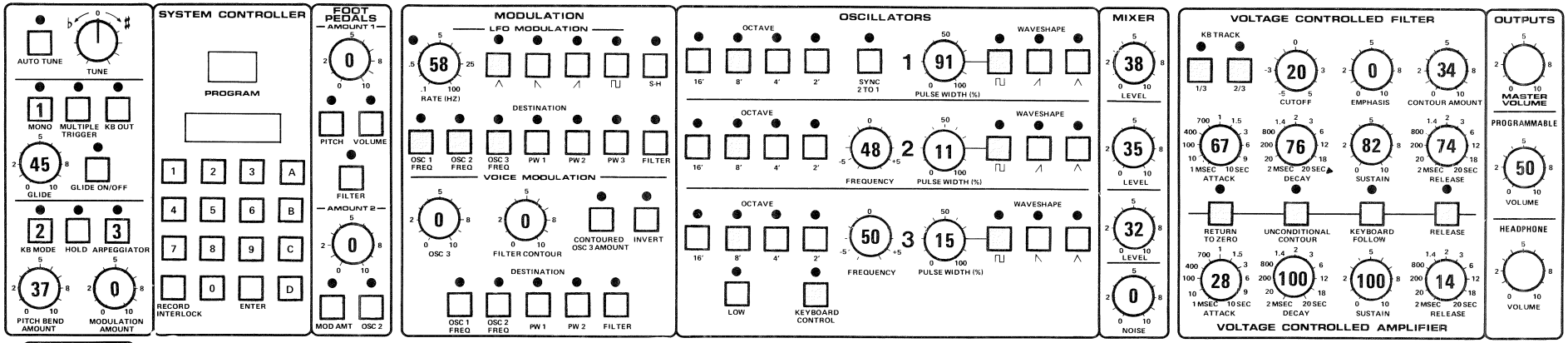
The "chime" effect builds up if keys are held down longer.

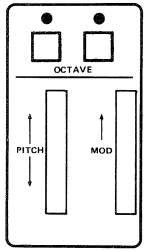




51. STRING 6

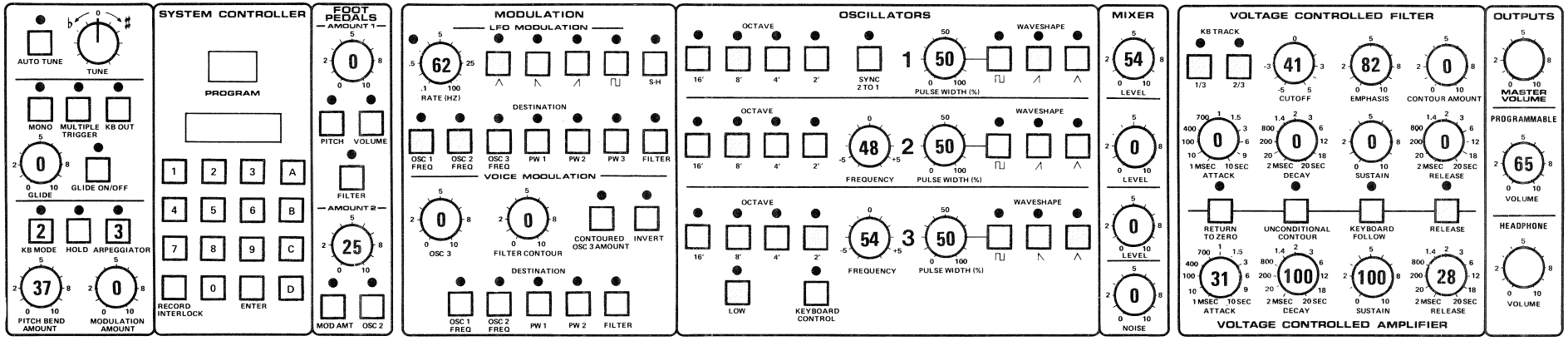
Short, articulated playing will accentuate the "bowing" sound.
Pedal 1 can control volume.

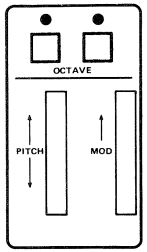




52. BRASS 6

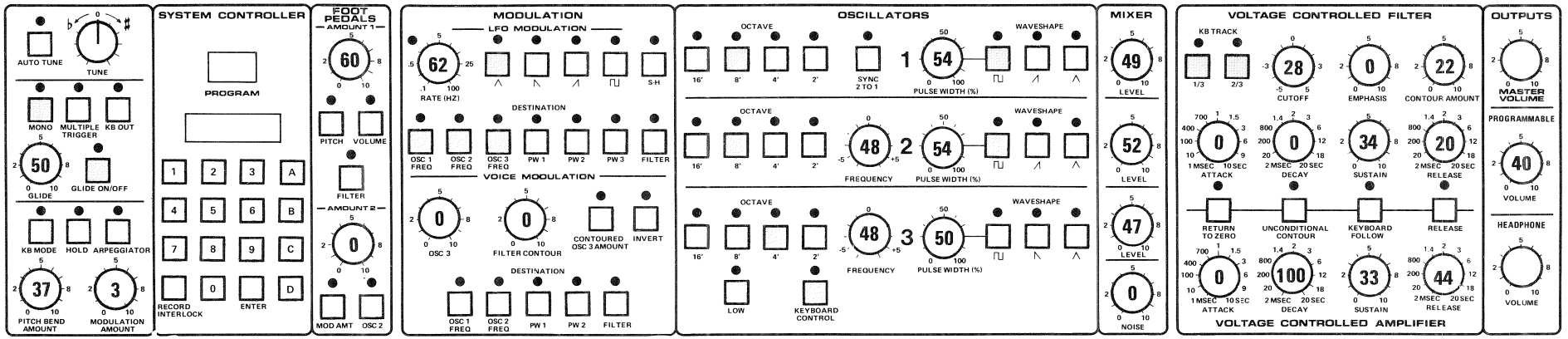
This voice differs from most brass patches in that no sawtooth waves are used. The Mod Wheel will introduce vibrato.

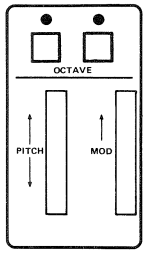




53. DOUBLE REED

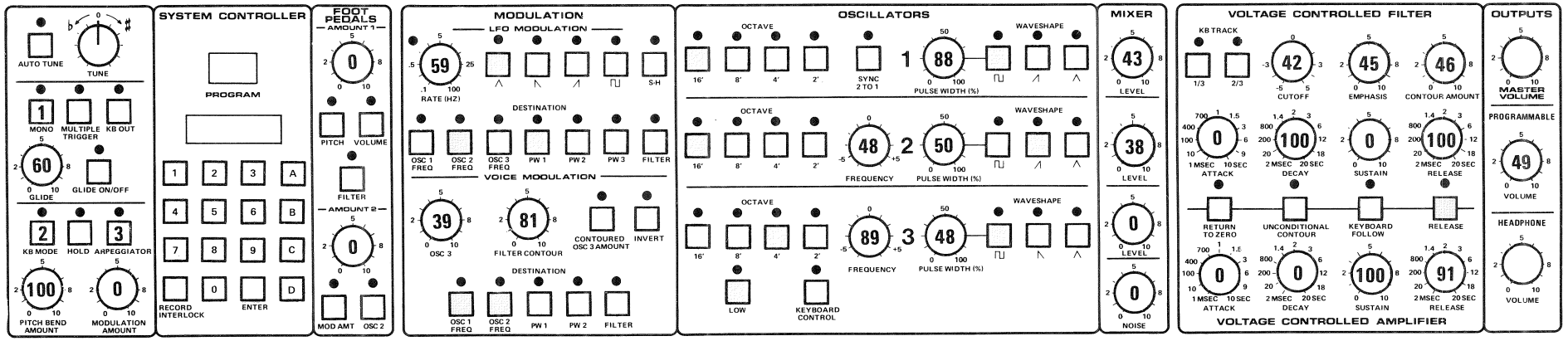
A high Emphasis setting produces a characteristic double reed resonance. This voice is most effective in the upper register. The Mod Wheel and/or Pedal 2 will introduce vibrato.

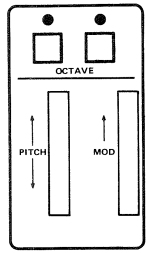




54. MONO 1

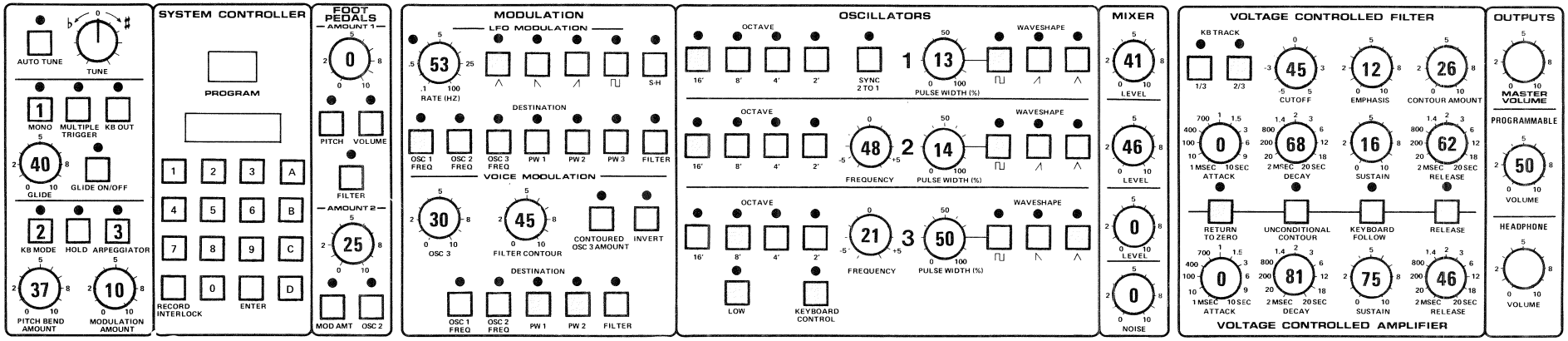
Experiment with the Pitch Bend and Mod Wheels. This voice is programmed for low-note priority; try the other modes. Pedal 1 will control Filter Cutoff.





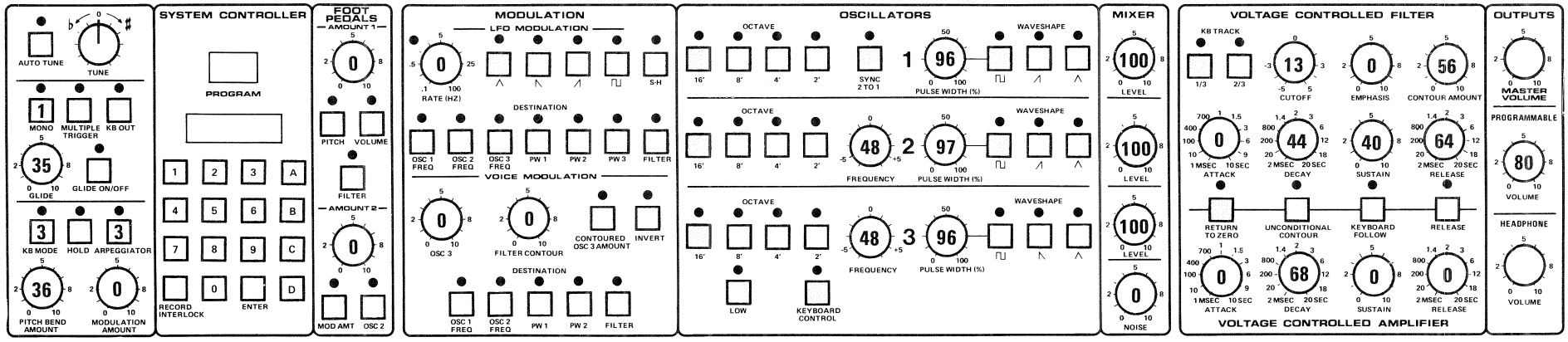
55. UFO

The Pitch Wheel is programmed at maximum; it can speed up, slow down, or reverse the falling effect.



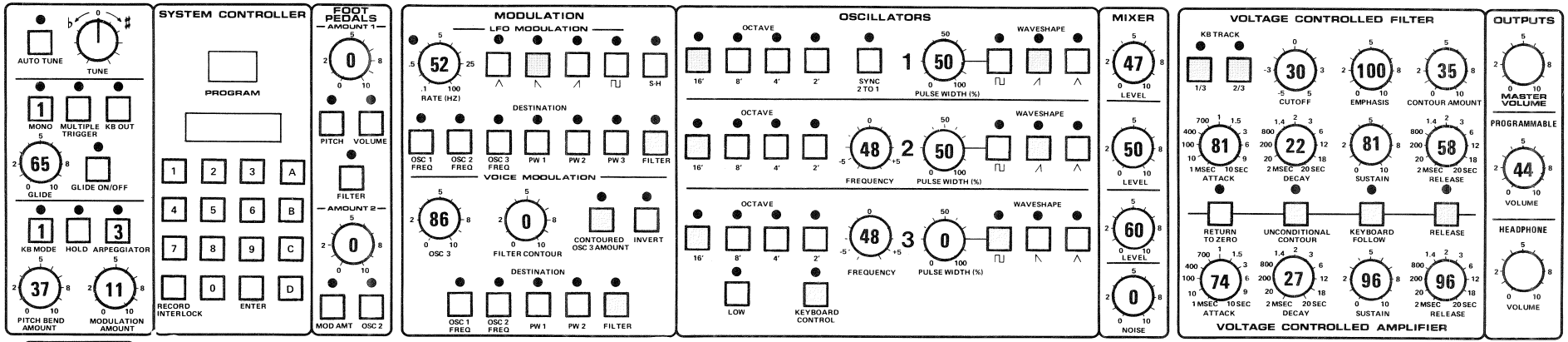
56. CHORUS SYNTH

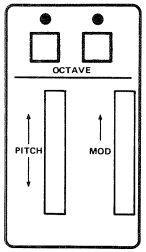
Try this voice with and without Glide. For more modulation, use Pedal 2 and/or the Mod Wheel.



57. CLAV 3

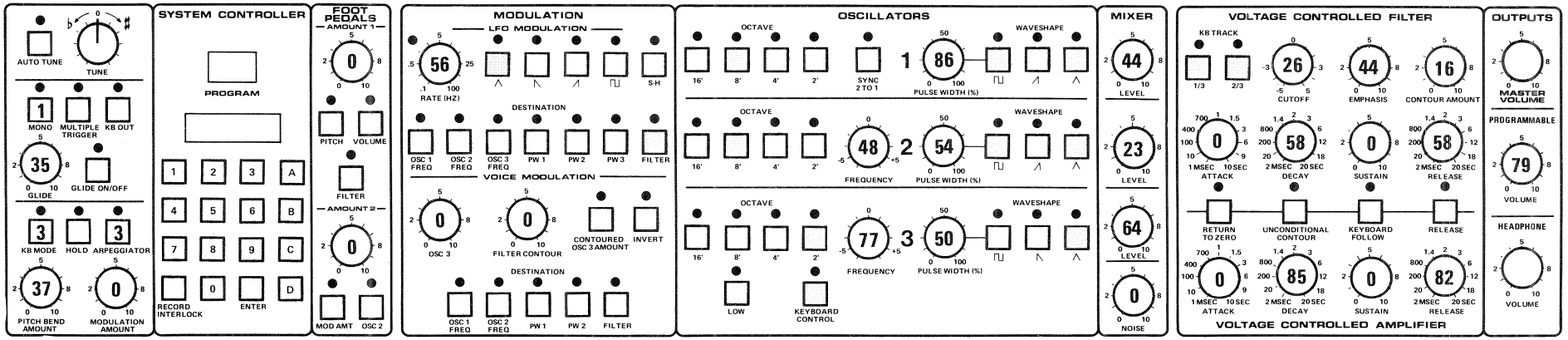
For a chorus clav sound, turn on the pulse waveshape for Osc 3.

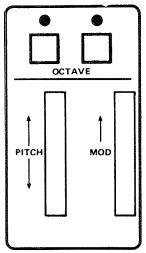




58. ECHO WHISTLE

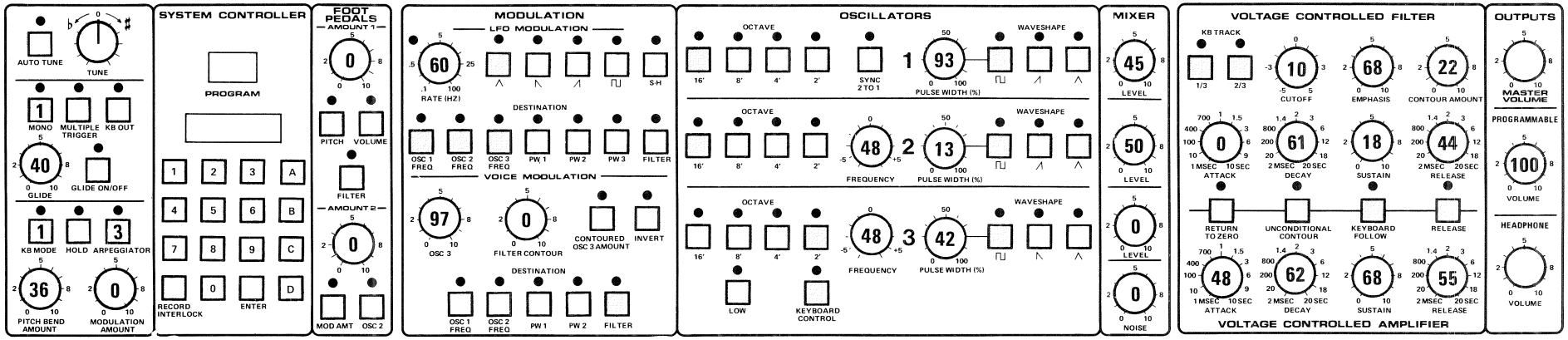
The echo effect will only be heard after a key is released. Because the Unconditional Contour is on, the Filter Contour will complete its attack stage before jumping to the release stage.





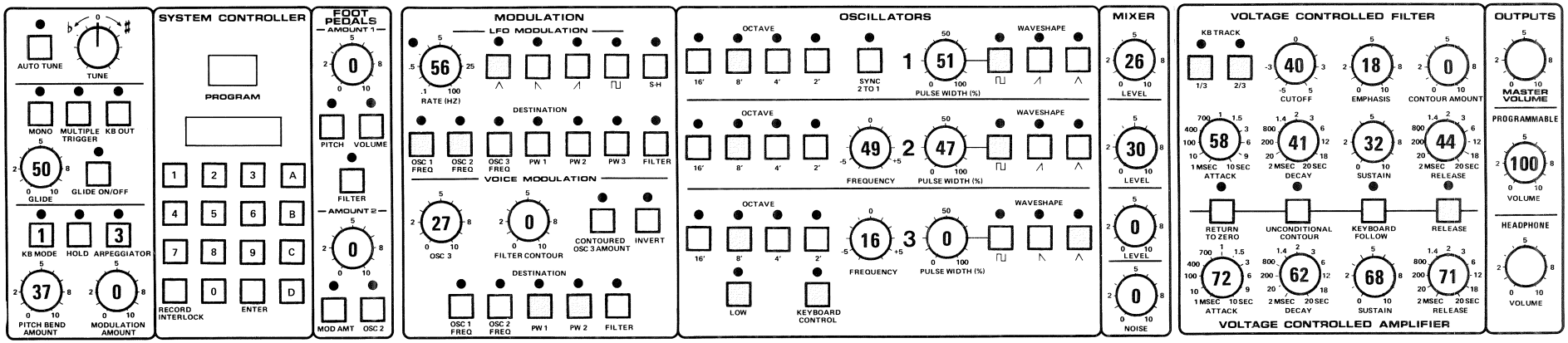
59. ELECTRIC PIANO 2

Advance the Mod Wheel for a tremolo effect.



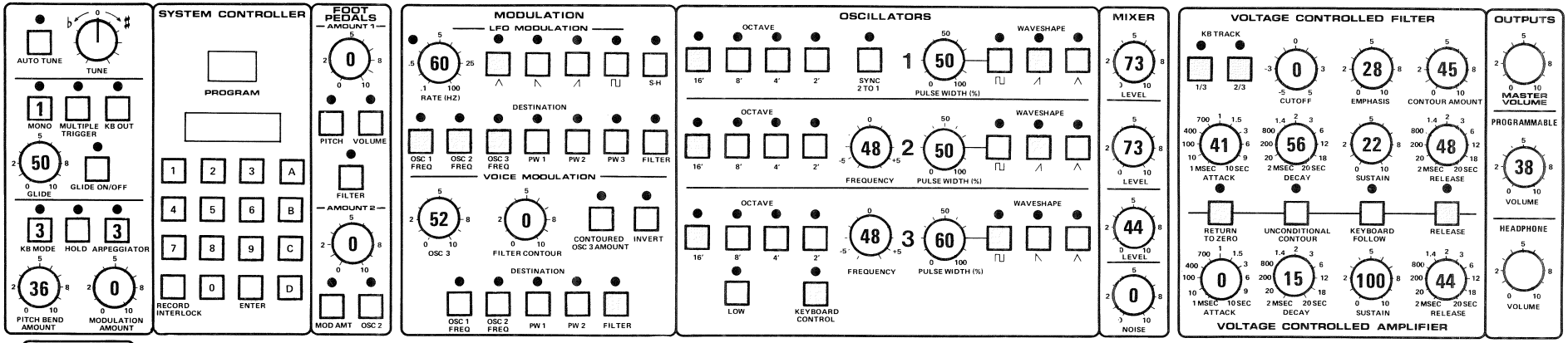
60. FM 1

This sound is produced by audio-range modulation of the Filter. The Mod Wheel will introduce vibrato.



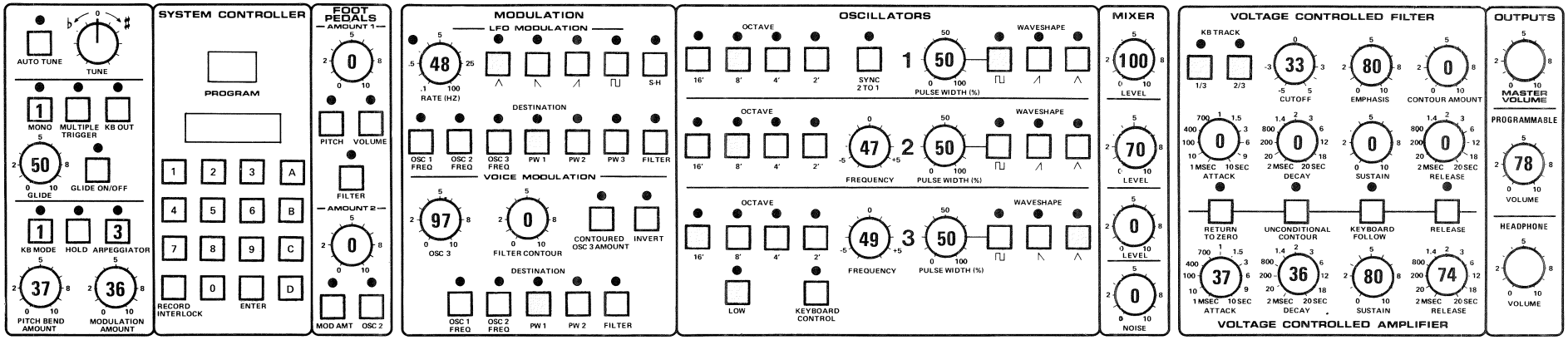
61. STRING 7

For more animation to the sound, advance the Mod Wheel 3/8 to 1/2.



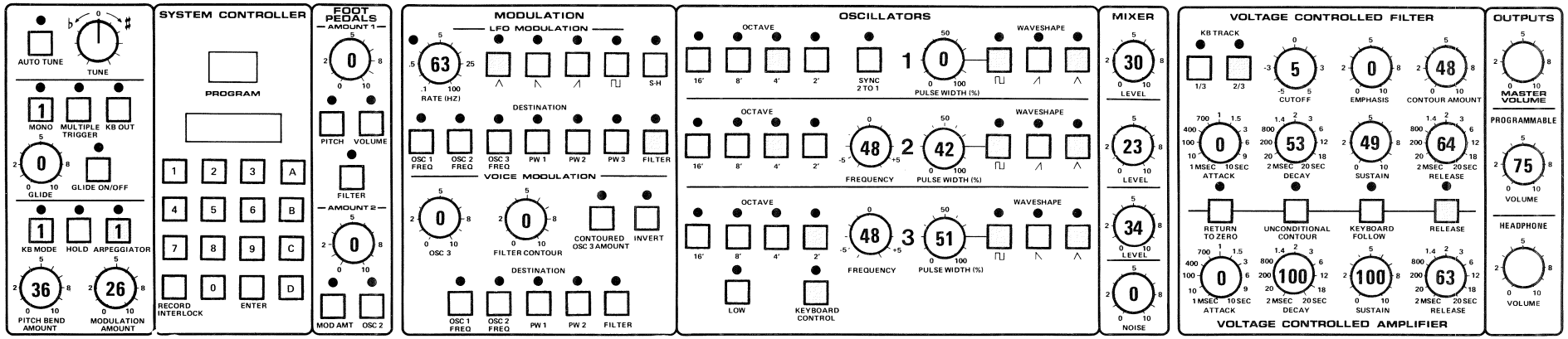
62. BRASS 7

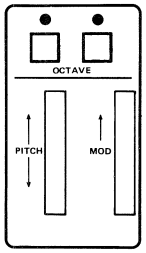
This voice is another example of audio-frequency filter modulation. Try different waveshape settings for Osc 3; note the change in timbre.



63. SYNTH ORGAN

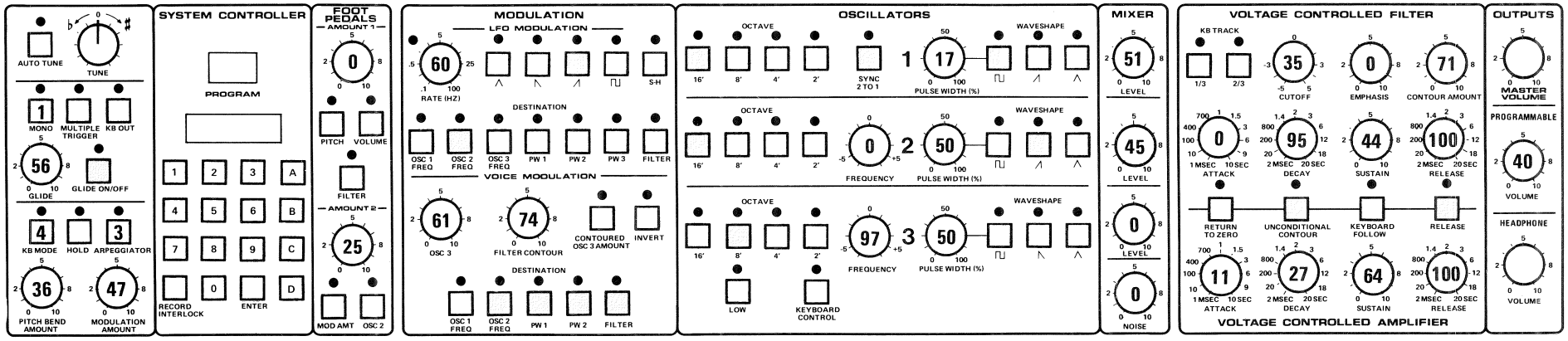
Switching the left-hand Octave setting will have a pronounced effect on the tone color of this voice.

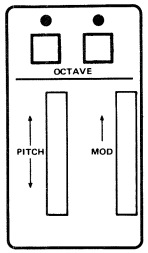




64. MONO 2

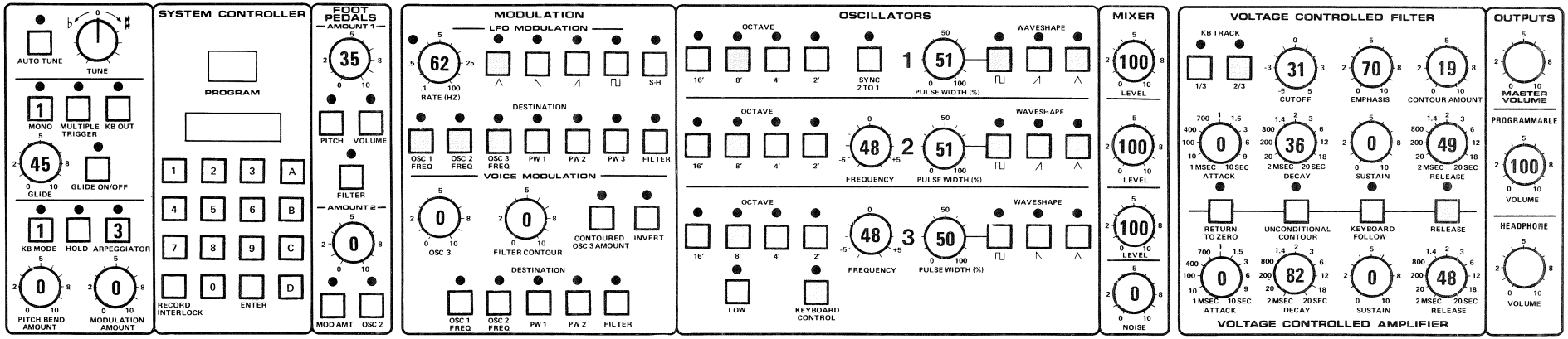
The LFO setting determines the speed of the Arpeggiator. At high speeds, the tremolo effect becomes more pronounced.





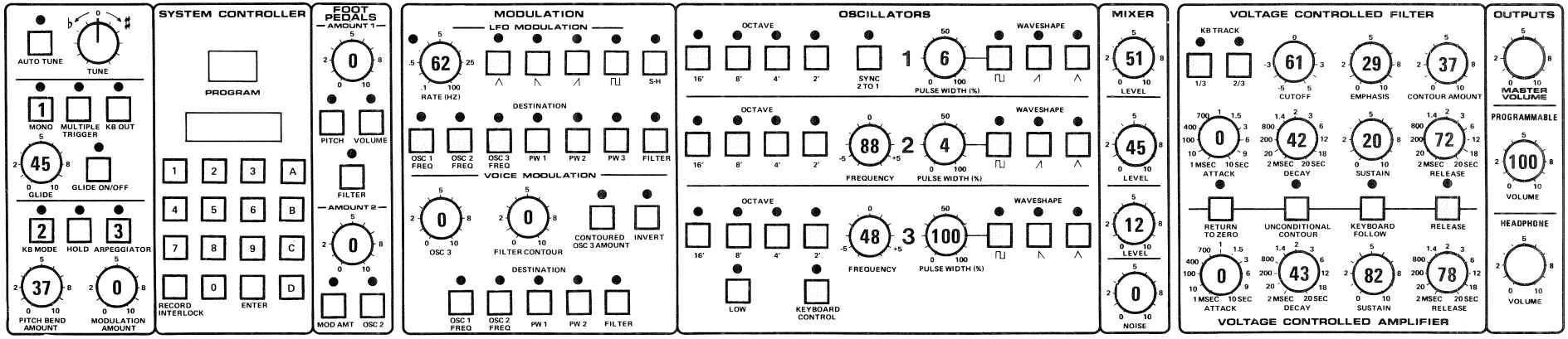
65. SYNC SWEEP 4

The reiterating effect comes from LFO Modulation; the long fall effect is from the Voice Modulation section. Pedal 2 controls additional sync effects.



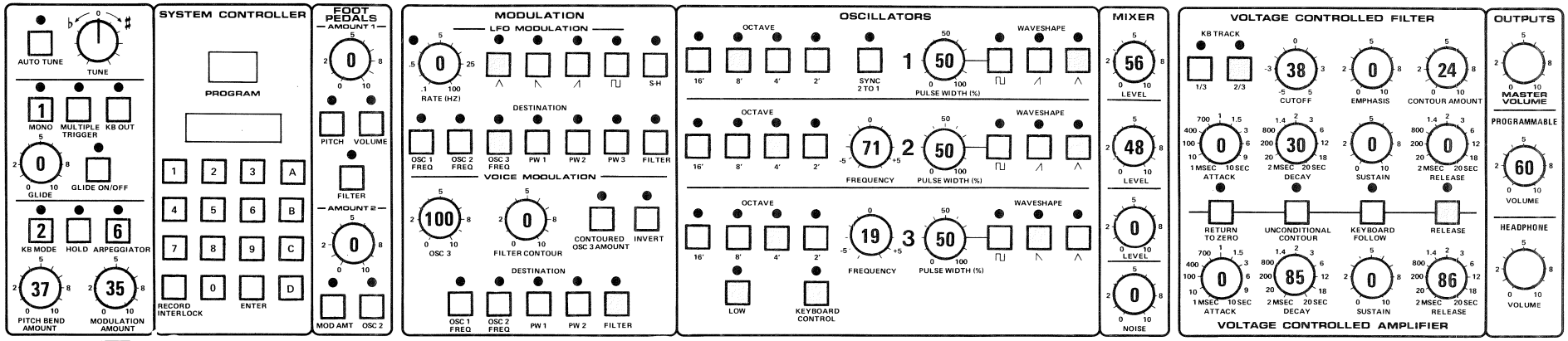
66. SQUARE WAVE 2

Pedal 1's control of the Filter will dramatically change the character of this voice.



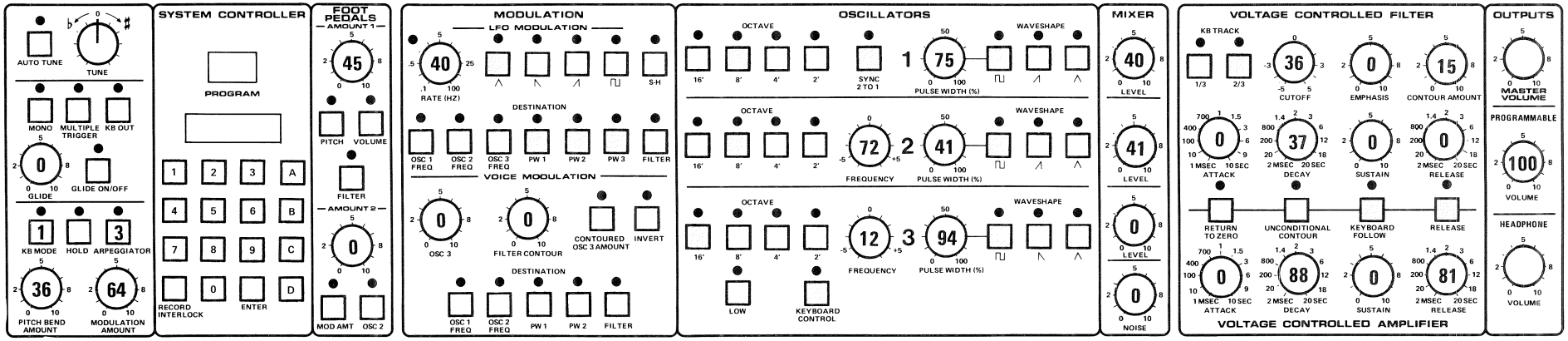
67. QUINT HARPSICHORD

Modulation (vibrato) can be introduced with the Mod Wheel.



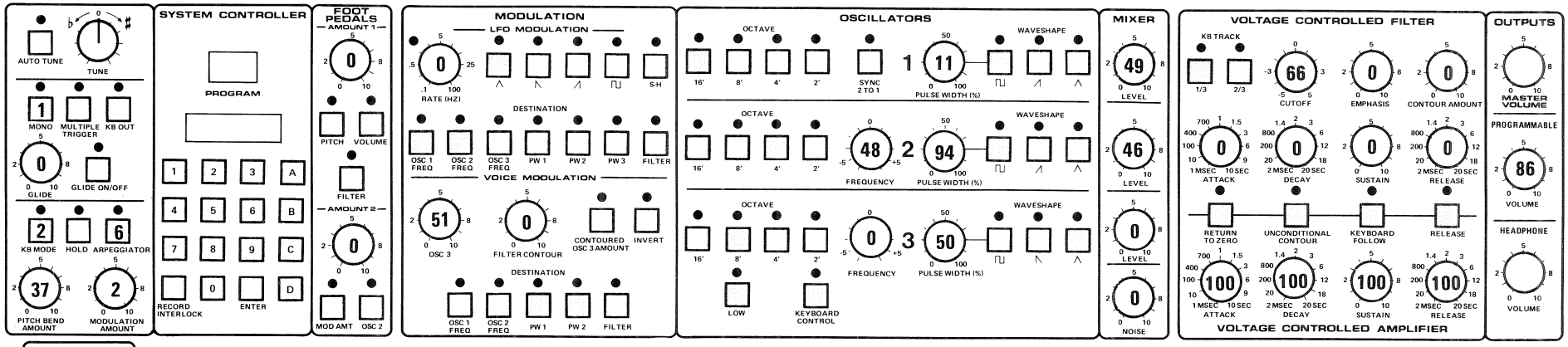
68. WIND CHIMES 2

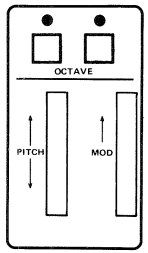
This is an example of "cascaded" modulation; the LFO modulates Osc 3, which in turn modulates the Filter. Note that the chime effect on any one voice subtly speeds up and slows down.



69. ELECTRIC PIANO 3

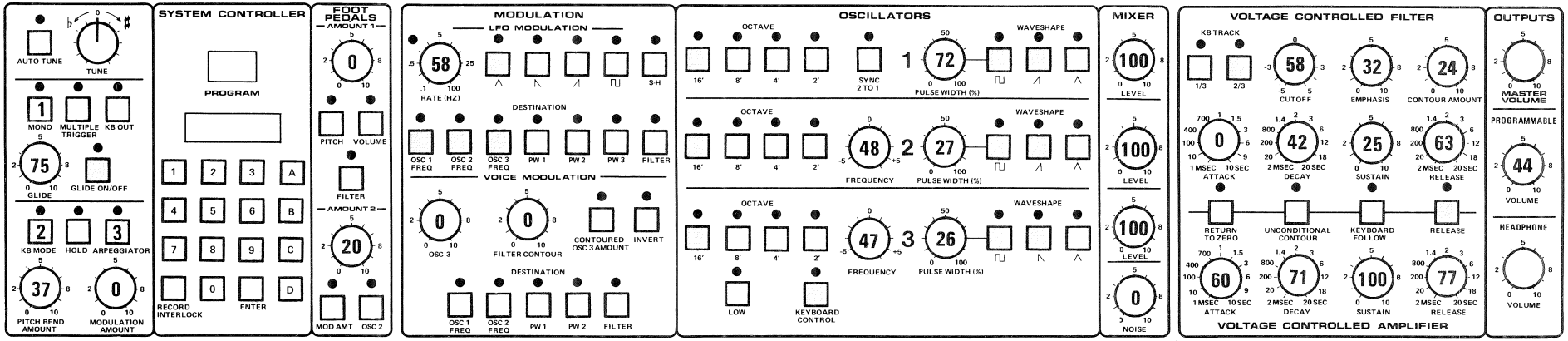
For more animation in the sound, turn up the Mod Wheel. Pedal 1 will control brightness.

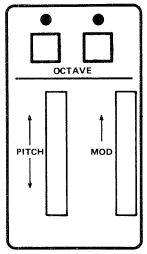




70. BOWED OCTAVES

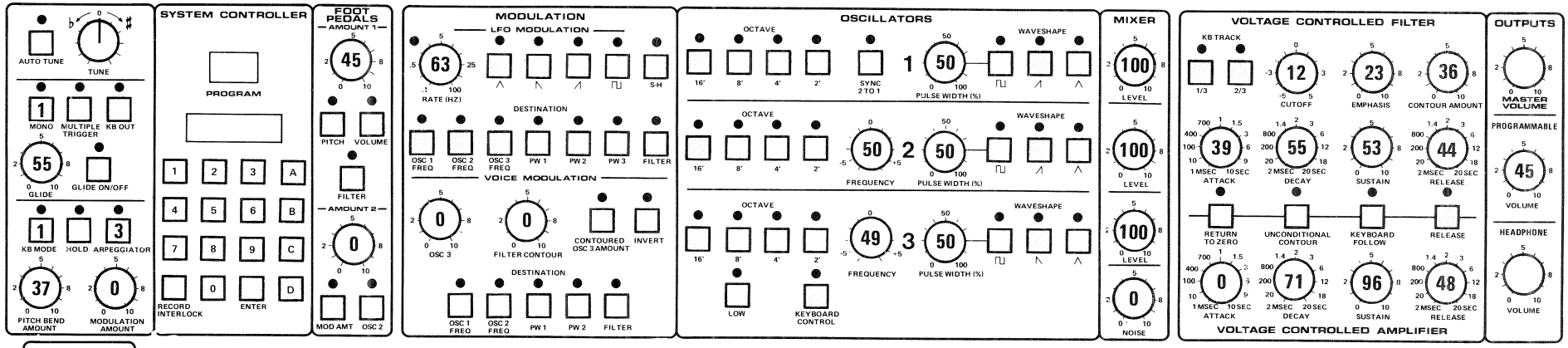
The key to this patch is using pulse waves that are nearly mirror images: Osc 1 at 11%, Osc 2 at 94%. The Voice Modulation section first drives one oscillator to 0%, then the other, resulting in a smooth transition between octaves.

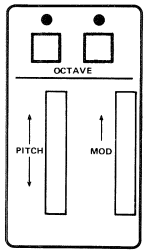




71. STRING 8

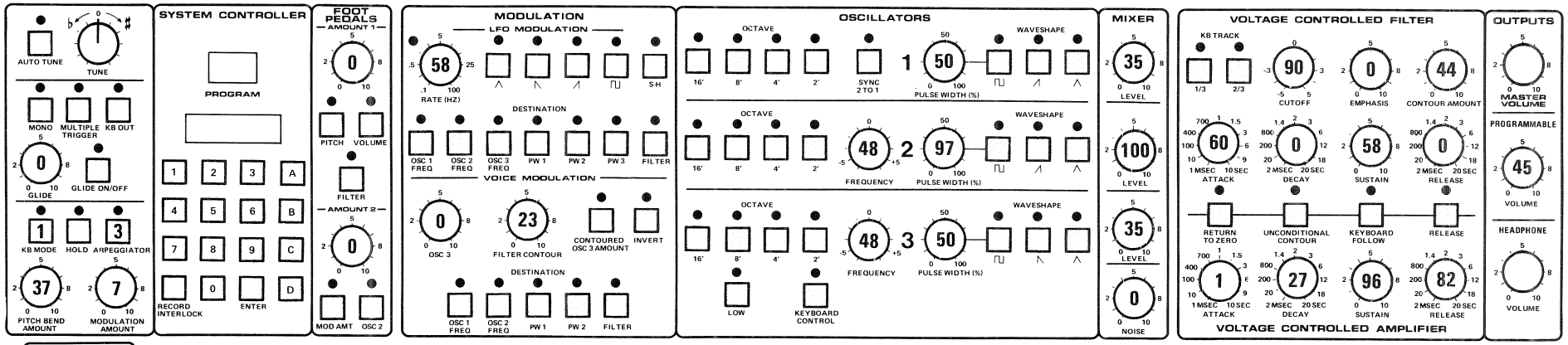
Additional modulation can be introduced from Pedal 2 and/or the Mod Wheel.

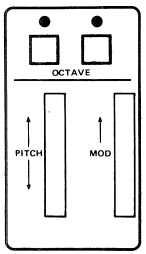




72. BRASS 8

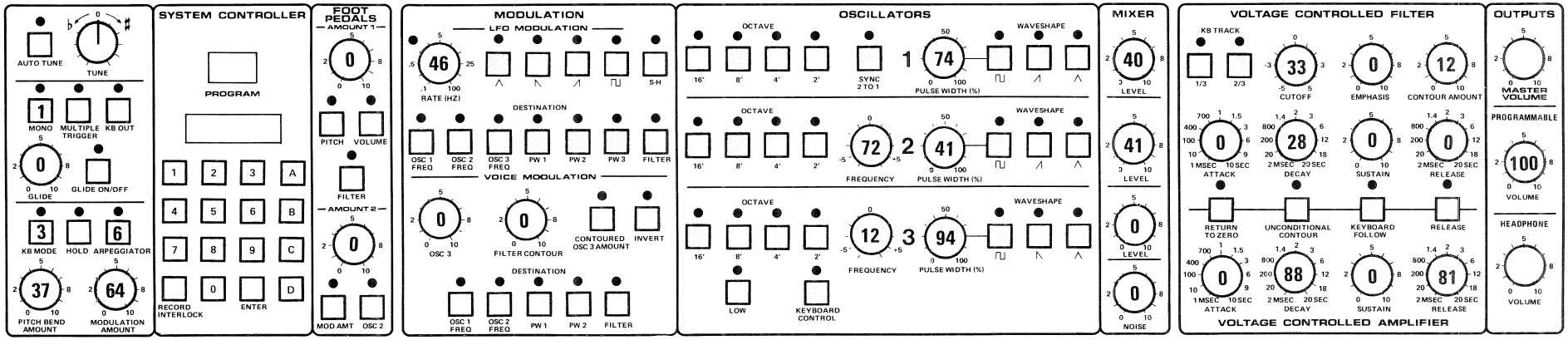
Try this voice with and without Glide. Vibrato is available at the Mod Wheel.

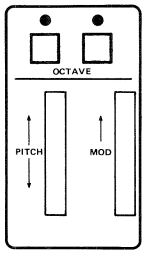




73. RELEASE VOICE

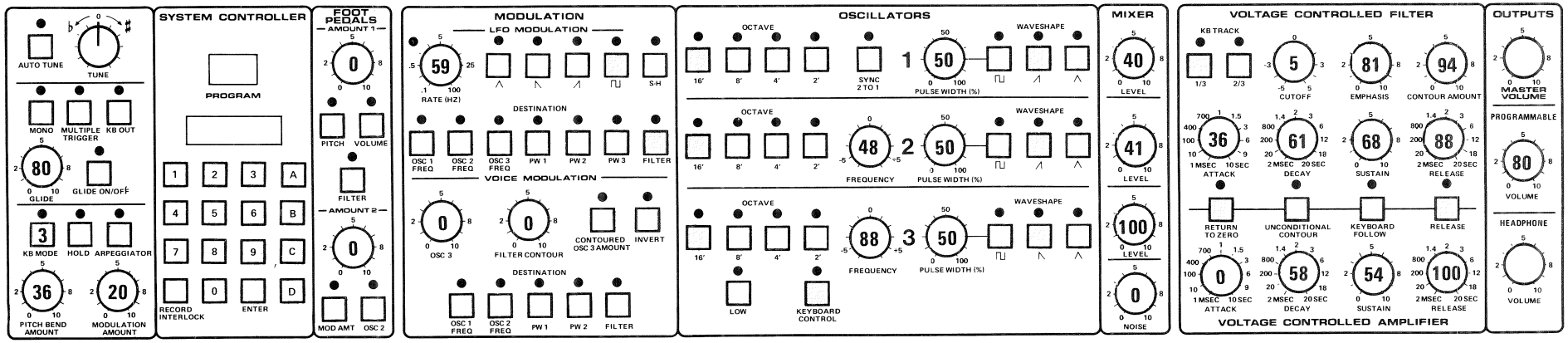
The Voice Modulation section drives the pulse signal of Osc 2 to zero while keys are held down; when the keys are released, the second oscillator can sound.

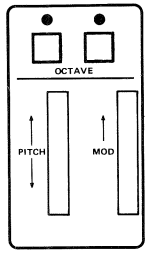




74. MONO 3

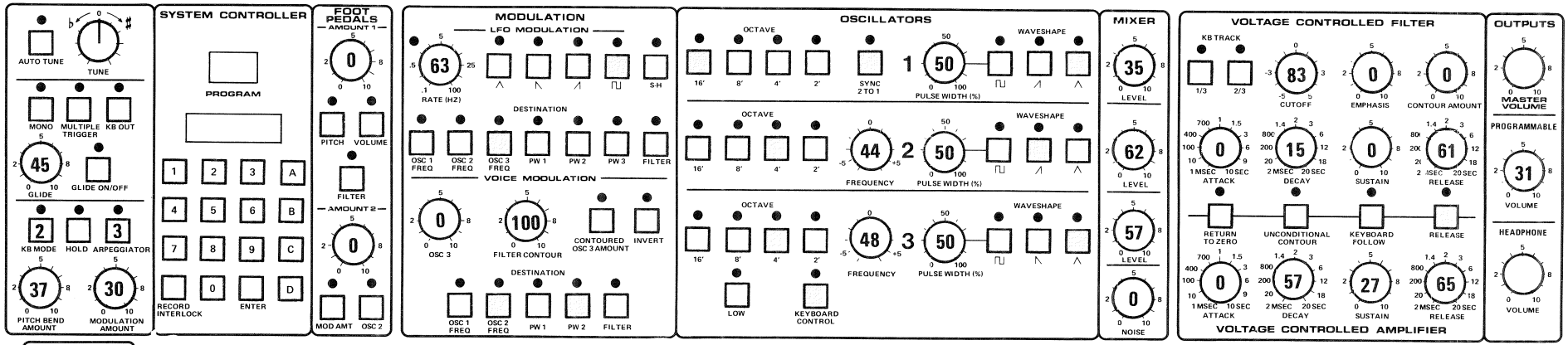
This is not a true mono voice; only one voice card is triggered at a time, but the long release allows voices to overlap.

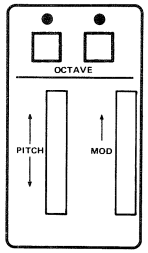




75. QUINT FILTER TRILL

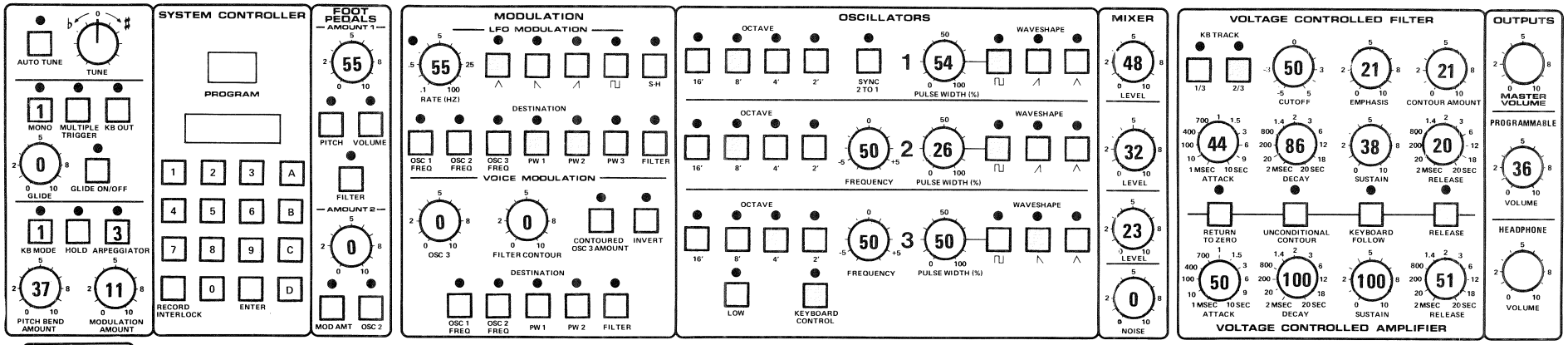
The high Filter Sustain level keeps the trill effect from "falling" until keys are released.

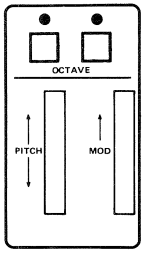




76. QUINT OSCILLATOR TRILL

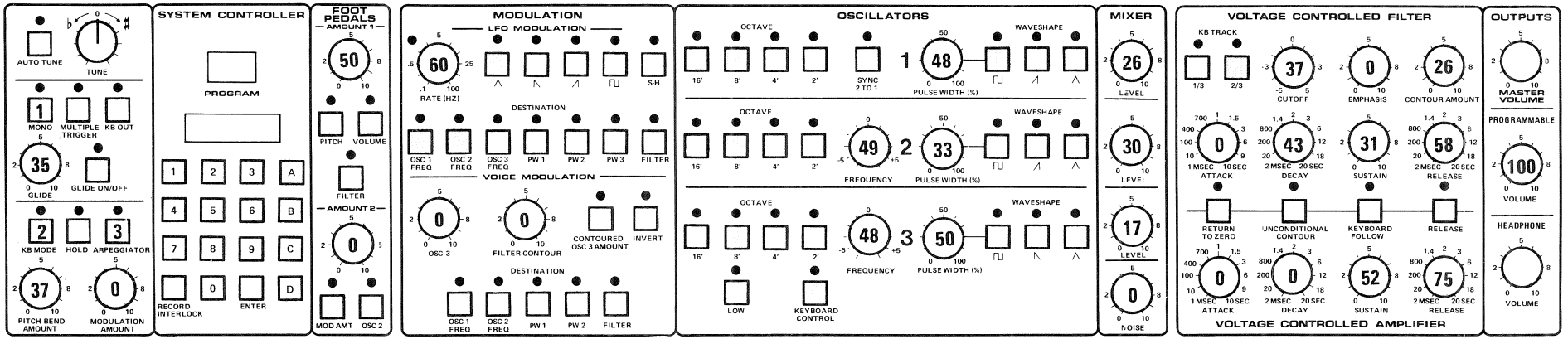
The interval trill is produced by the LFO Modulation section; the "thump" on the beginning of each note is produced by the Voice Modulation section.





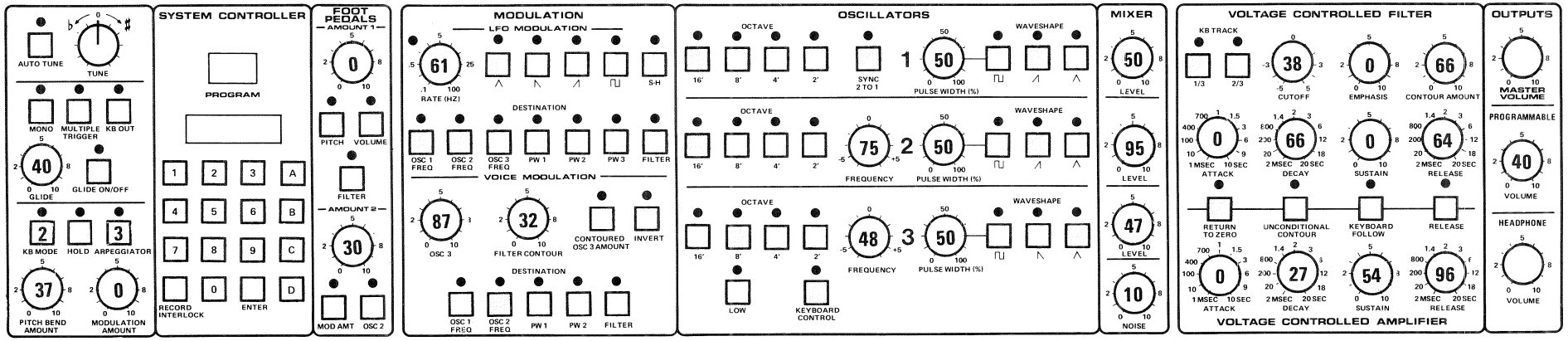
77. ACCORDION

The detuning of Oscillators 2 and 3 produces the "musette" effect; for a different effect, hit C, hit 5, hit ENTER.



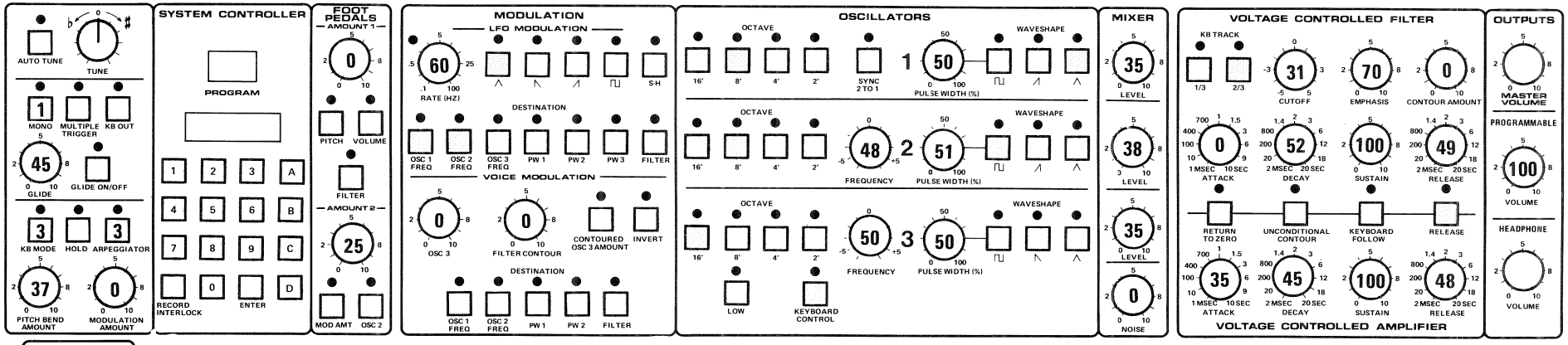
78. SYNTH PLECTRUM

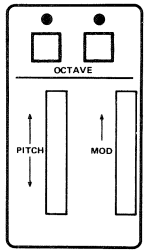
Pedal 2 can control Filter Cutoff; the Mod Wheel will introduce vibrato.



79. SYNC 5

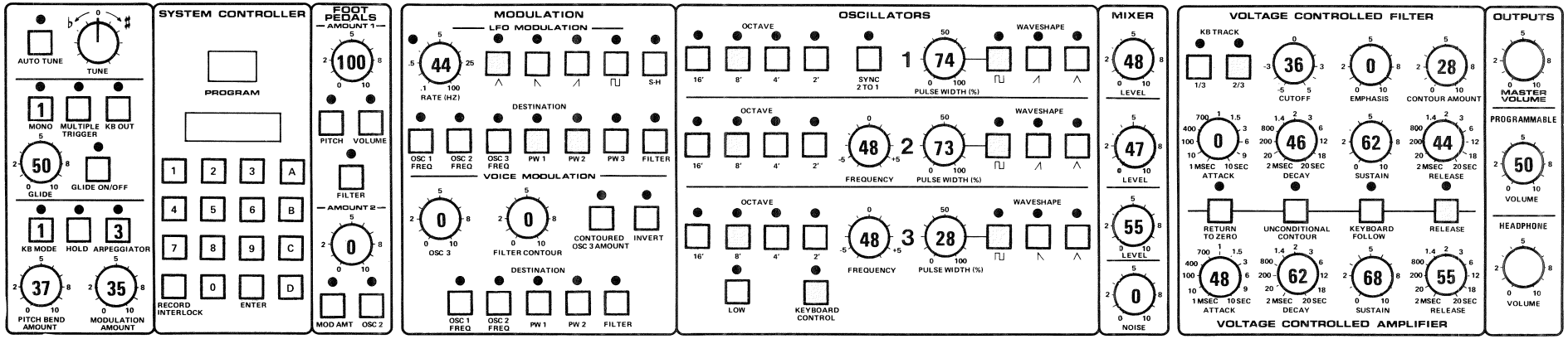
Pedal 2 can be used to change the basic tone color of the initial sound; the Mod Wheel will add vibrato.

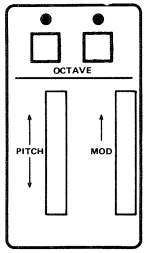




80. SYNTH WOODWINDS

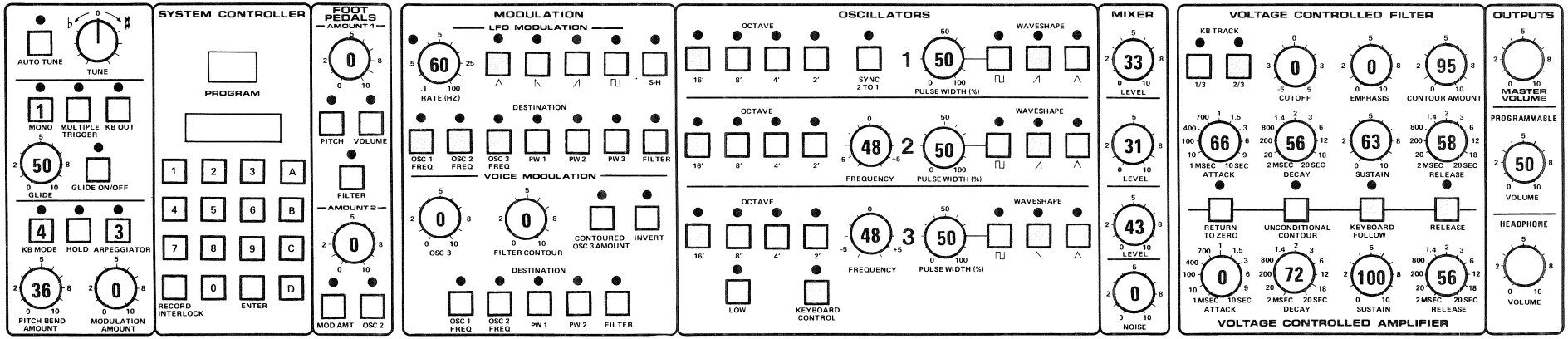
Modulation (vibrato) can be added via Pedal 2 and/or the Mod Wheel.

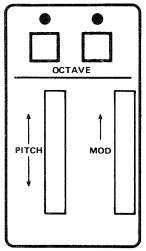




81. STRING 9

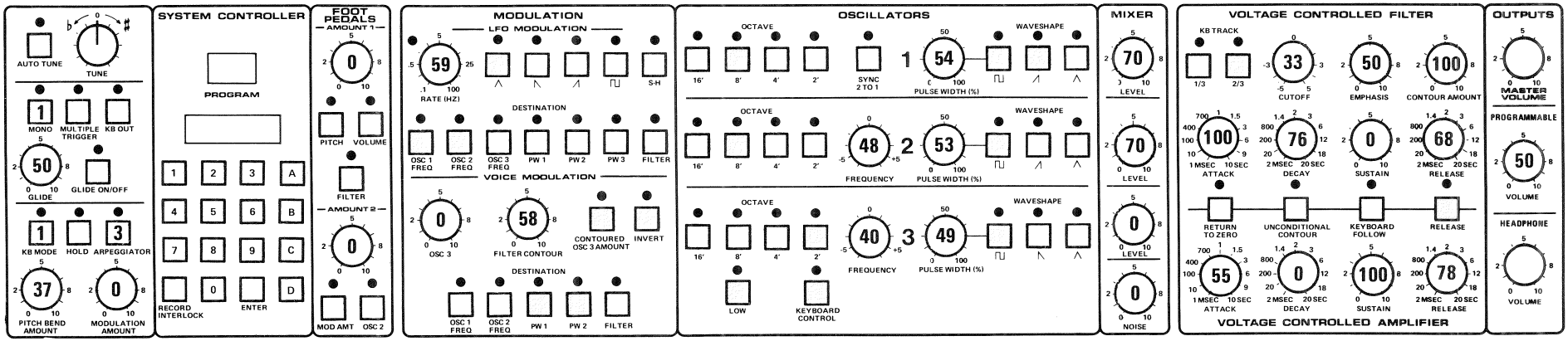
Short, articulated playing will accentuate the "bowing" effect in this voice.

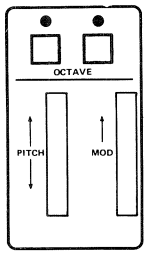




82. BRASS 9

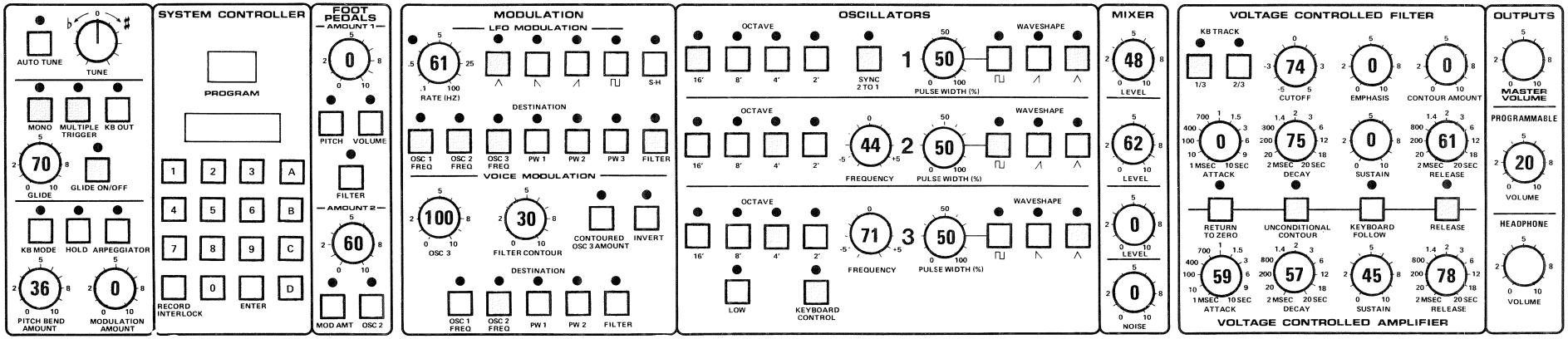
The Keyboard Follow produces faster contours for higher notes in a manner characteristic of conventional brass instructions.





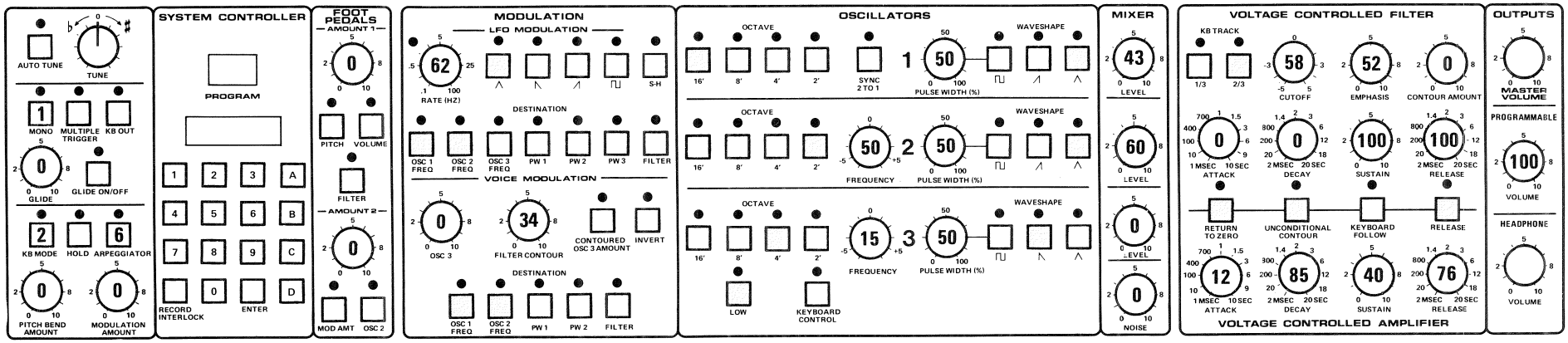
83. SURPRISE

Short notes produce a pleasant, flute-like timbre; the longer they're held, the nastier they get!



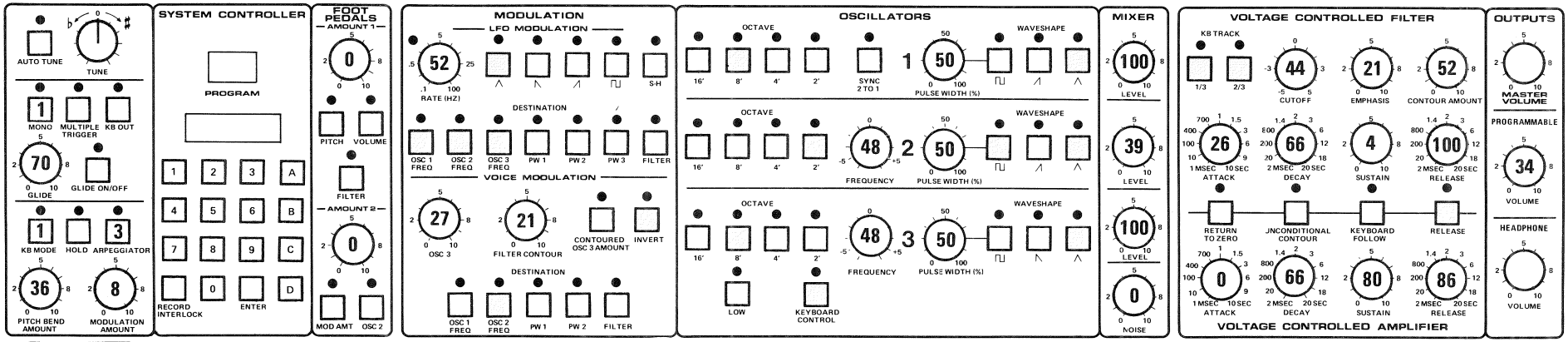
84. MONO 4

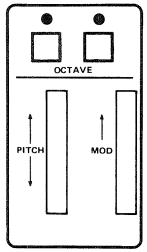
This is an example of audio-frequency modulation of the synced Osc 2. Note that multiple triggering is active; this ensures clean playing at rapid tempos.



85. DROPOFF

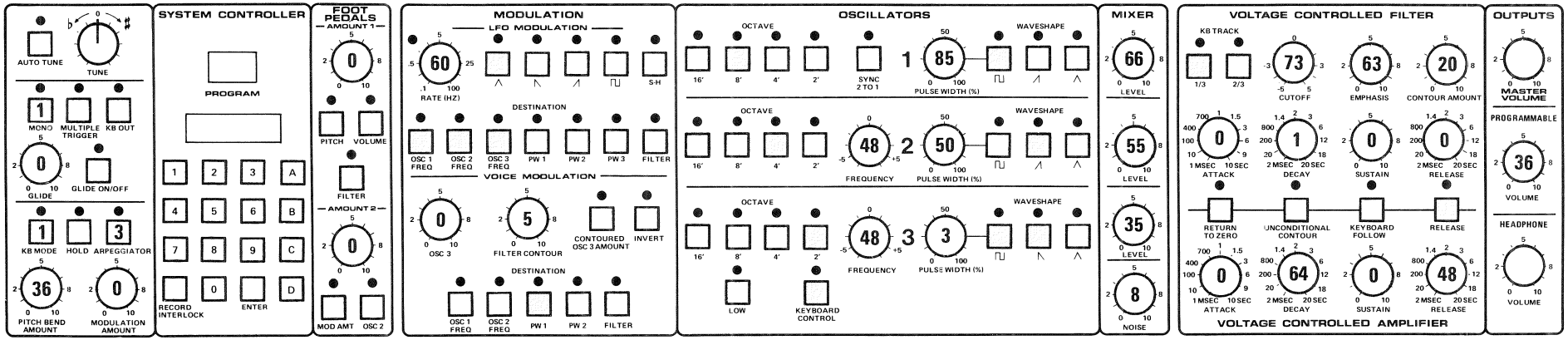
The dropoff effect will occur only when a key is released. The Filter Contour (with maximum sustain) is routed to the oscillators.

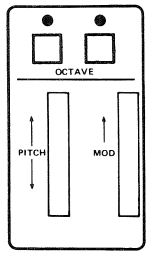




86. RING MOD

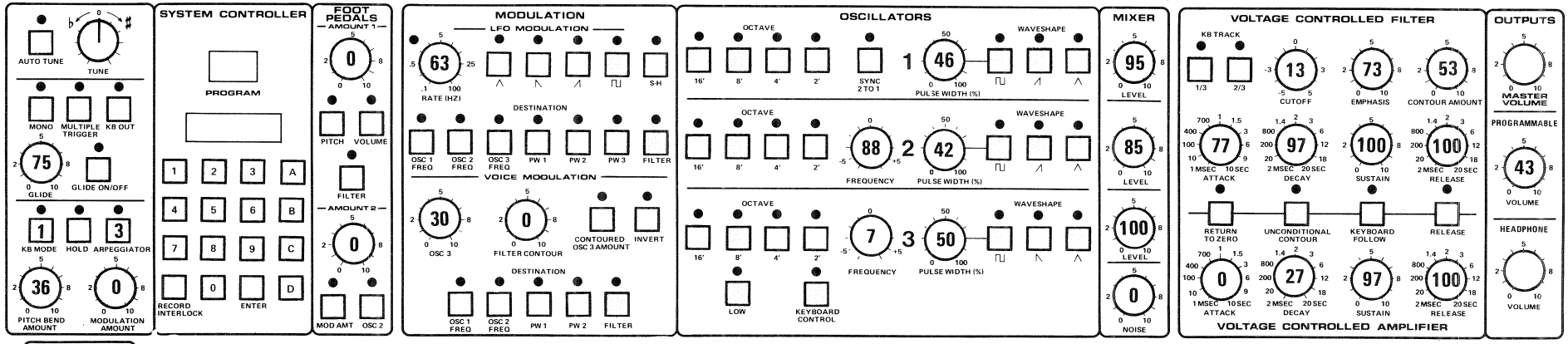
The ring mod effect shifts upward because the Filter Contour voltage sent to Osc 2 has been inverted.

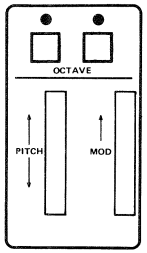




87. HARPSICHORD 2

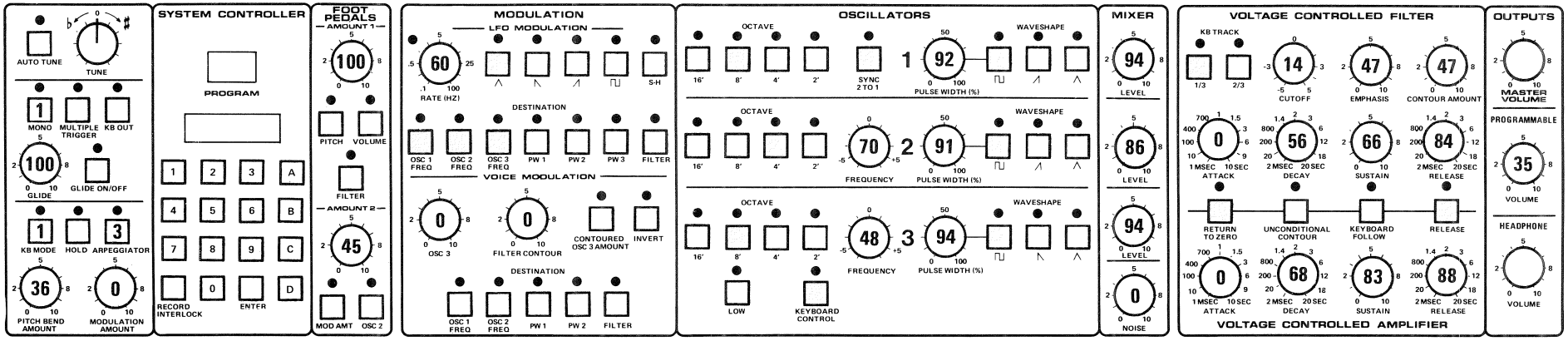
A small amount of Filter Contour sent to the pulse width of Osc 2 enhances the brilliance of the plucking effect.

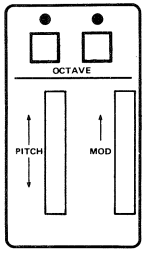




88. REPEAT VOICE

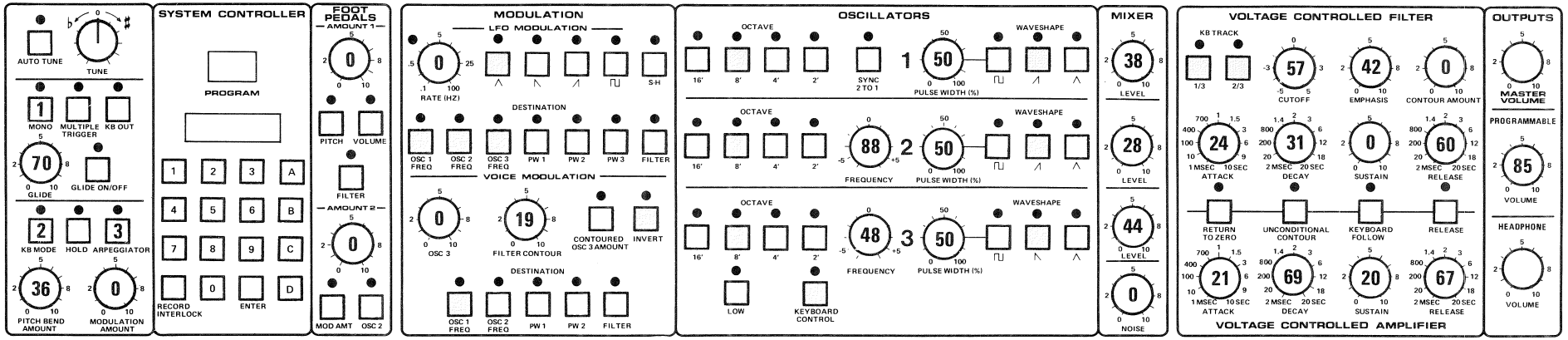
The low-frequency audio square wave and triangular waveshapes of Osc 3, in combination, form a unique kind of "reversing" waveshape (listen to a single note).

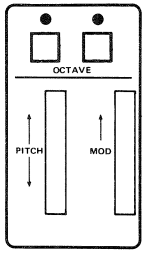




89. CLAV 4

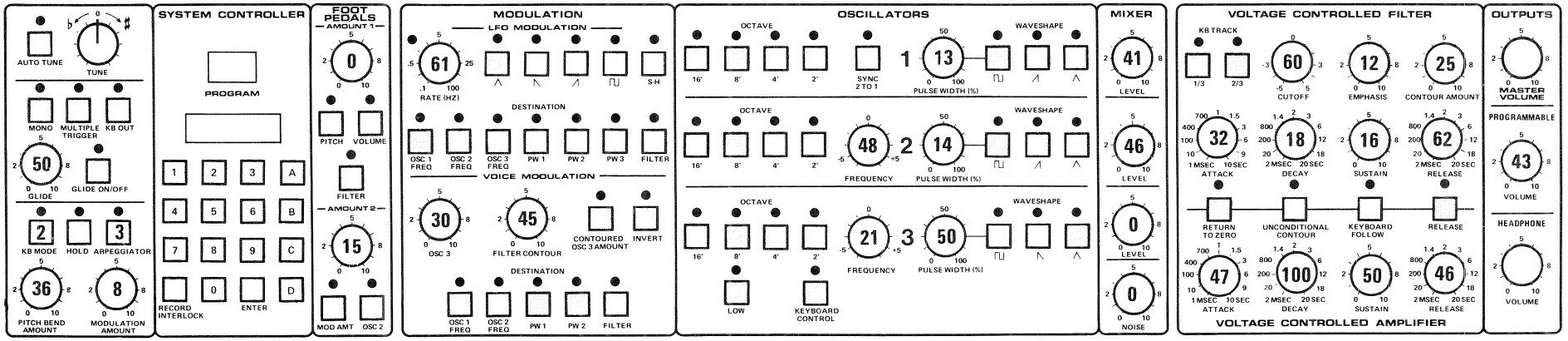
Try this voice with and without Glide. Pedal 1 can control brightness; Pedal 2 can add sync effects; the Mod Wheel will introduce vibrato.

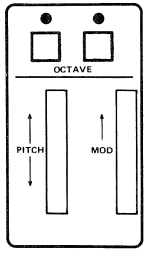




90. QUINT SYNTH

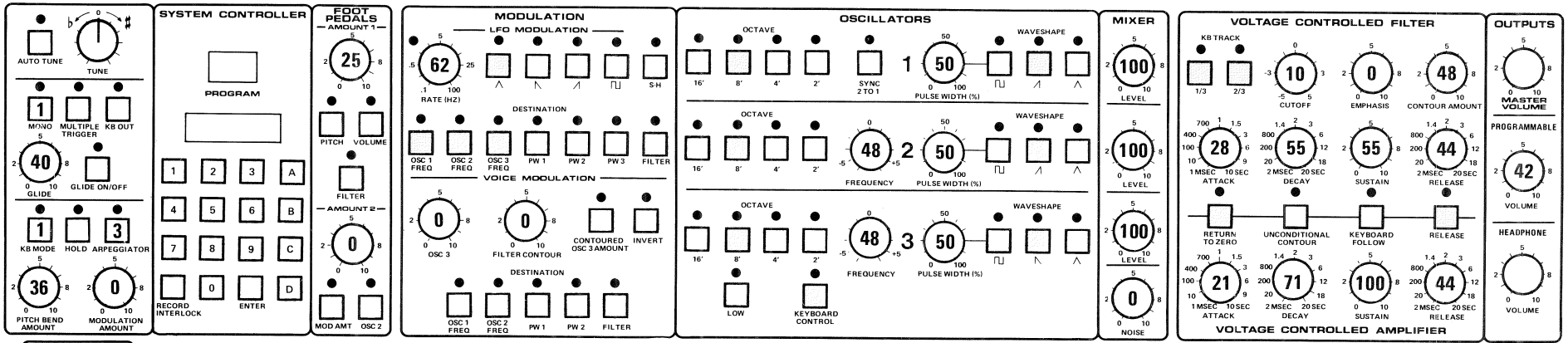
The inverted Filter Contour sent to Osc 1 puts a short "scoop" on the beginning of each note.





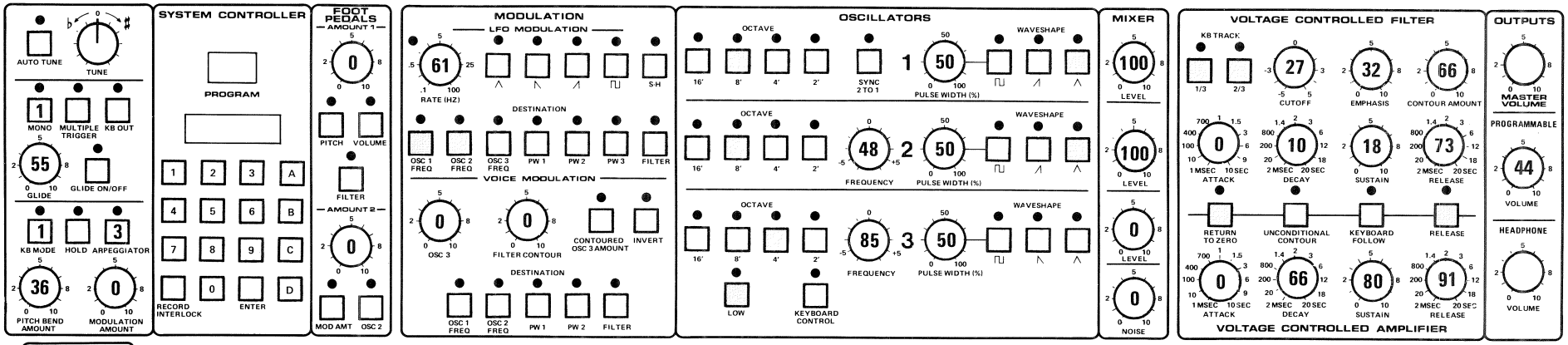
91. STRING 10

This string patch has a very pronounced "bowing" effect; try it with short, repeated chords.



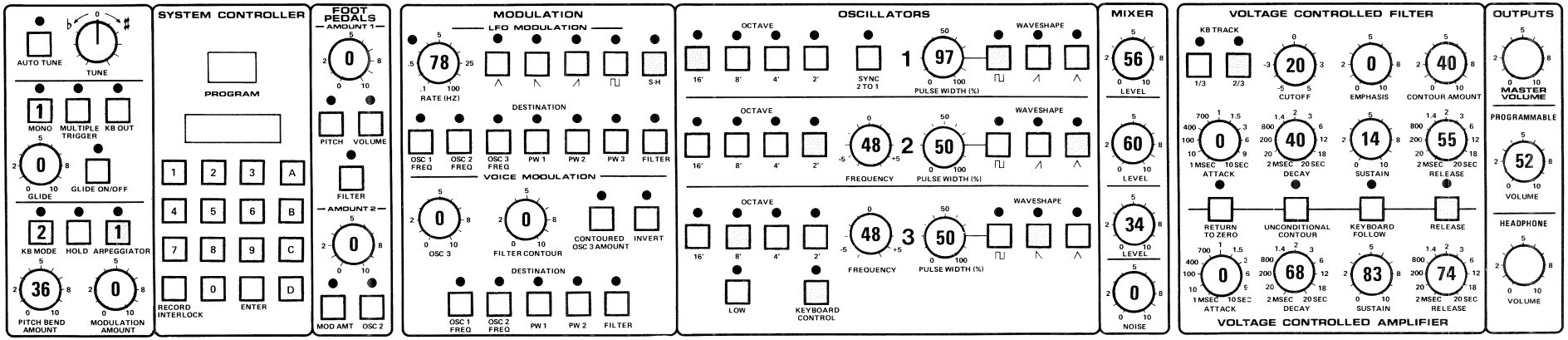
92. BRASS 10

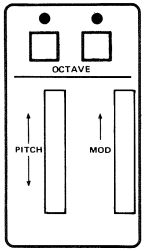
Modulation (vibrato) can be added via the Mod Wheel.



93. TRIANGLE WAVES

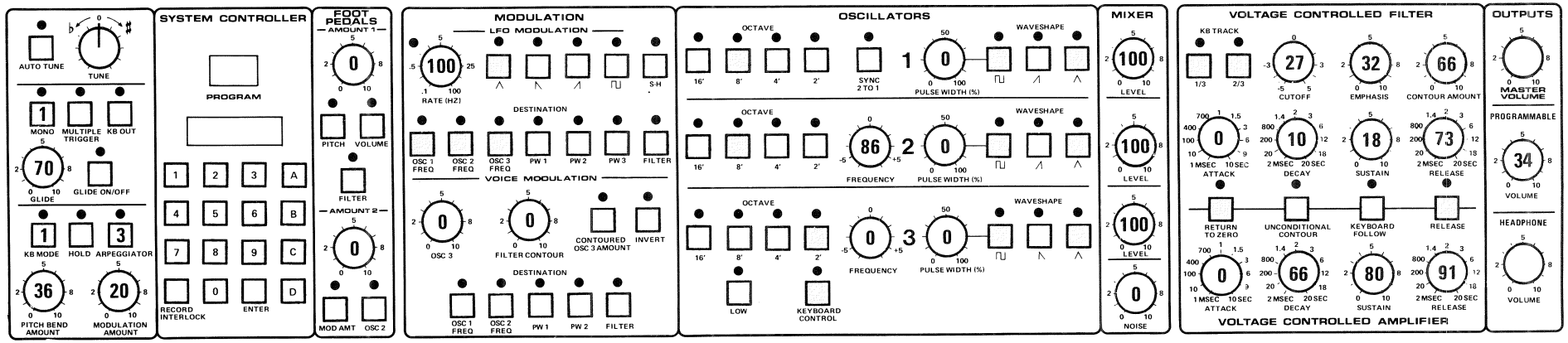
The triangle waves generate a basic signal unique to the synthesizer. Try this voice with and without Glide.

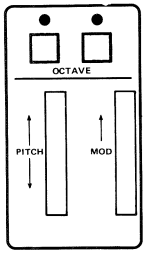




94. MONO 5

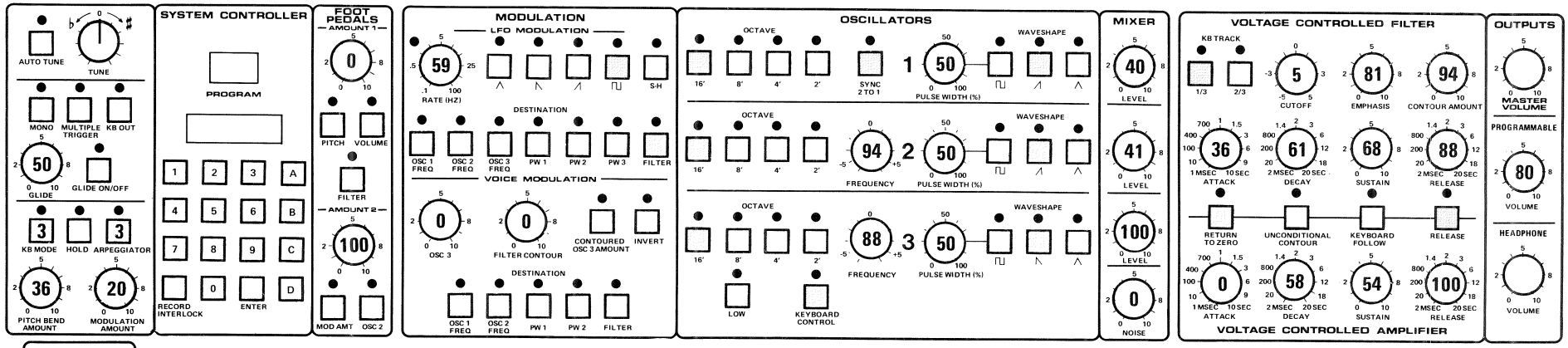
Holding down thirds (or other chords) produces a very authentic marimba sound.

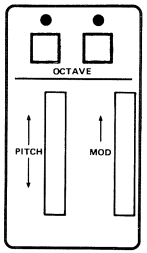




95. RING MOD 2

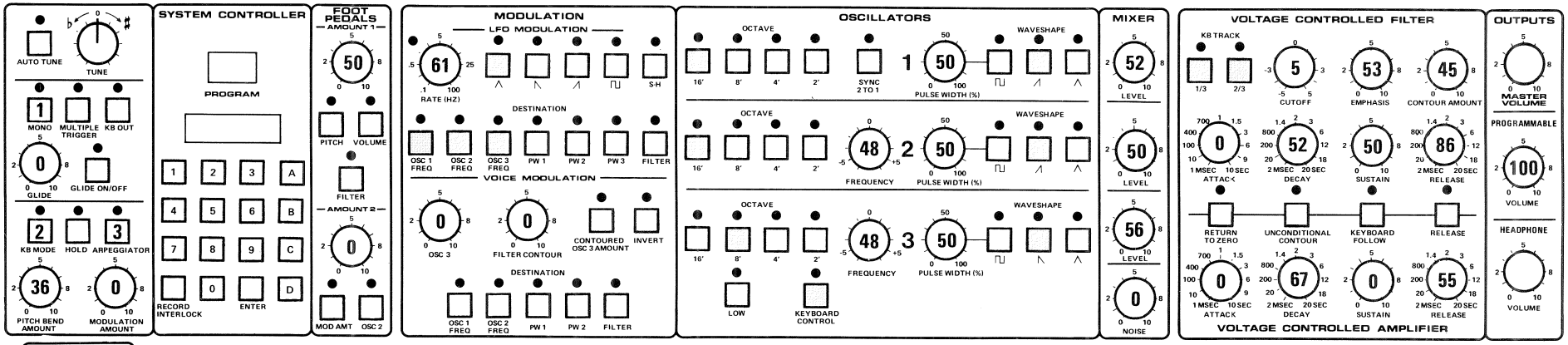
In this patch, the "ring mod" (audio-frequency modulation) is sent equally to all three oscillators.

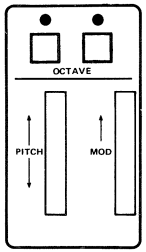




96. DUPE # 75

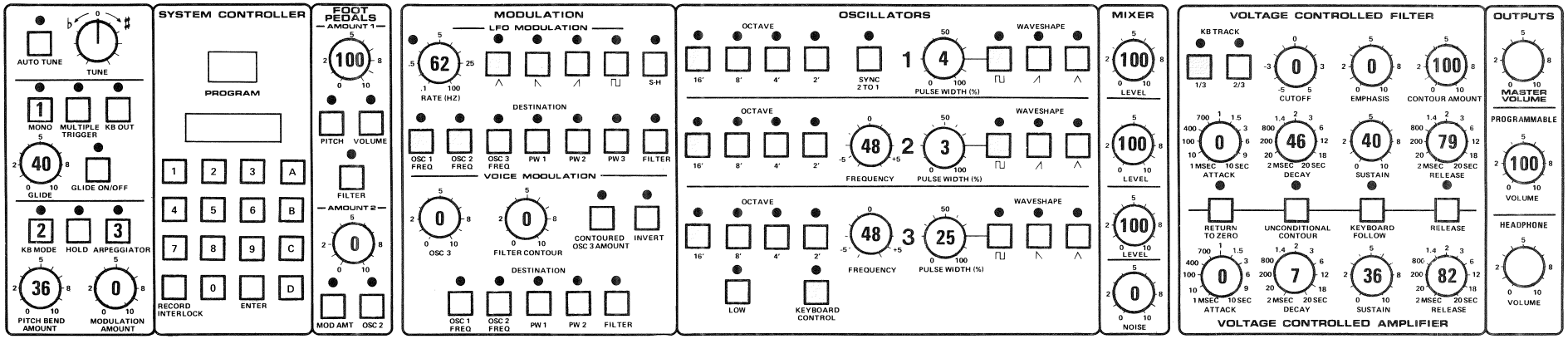
This is a "free" position, useful if you need a temporary holding position while swapping program locations.





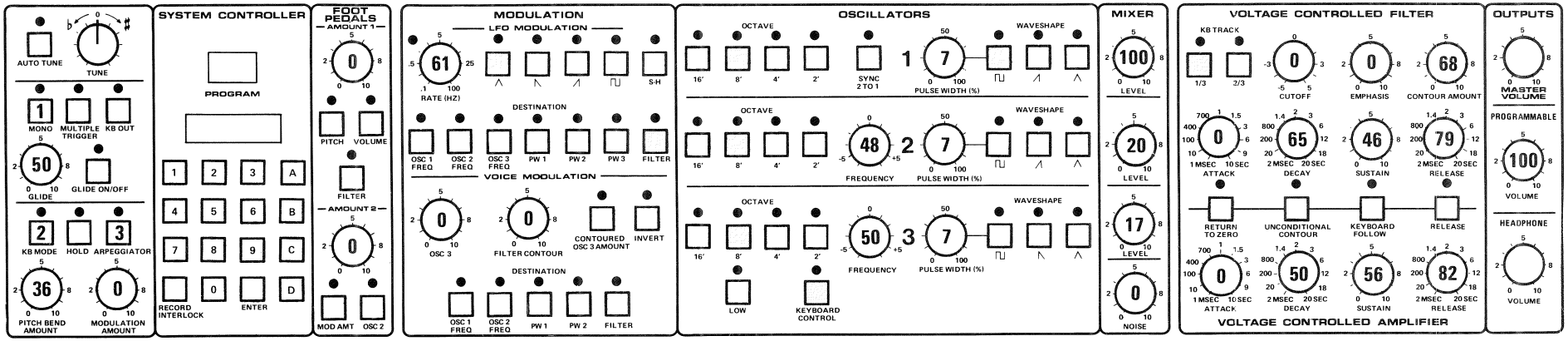
97. OCTAVE SYNTH 2

Pedal 1 can control Filter Cutoff (brightness); the Mod Wheel will add vibrato.



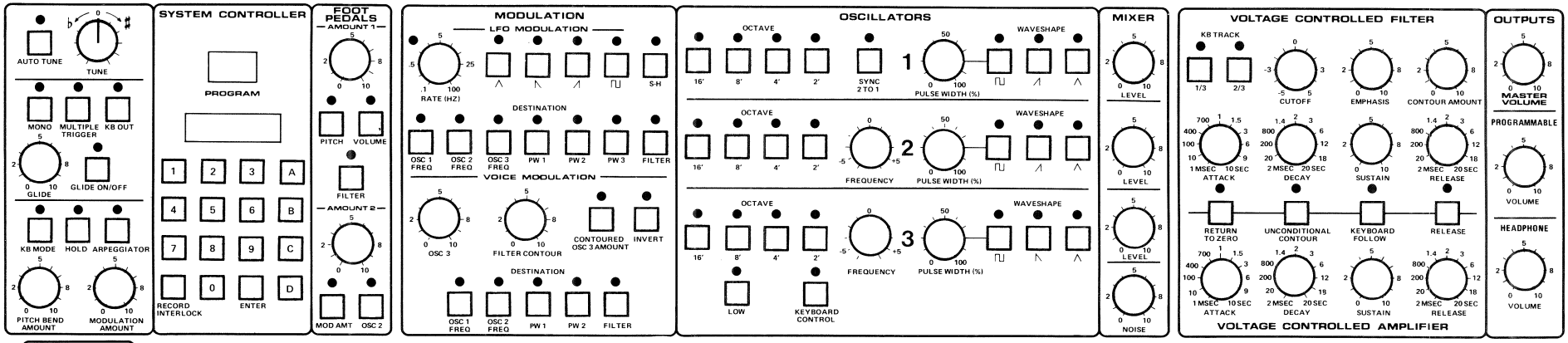
98. SYNTH PLECTRUM 2

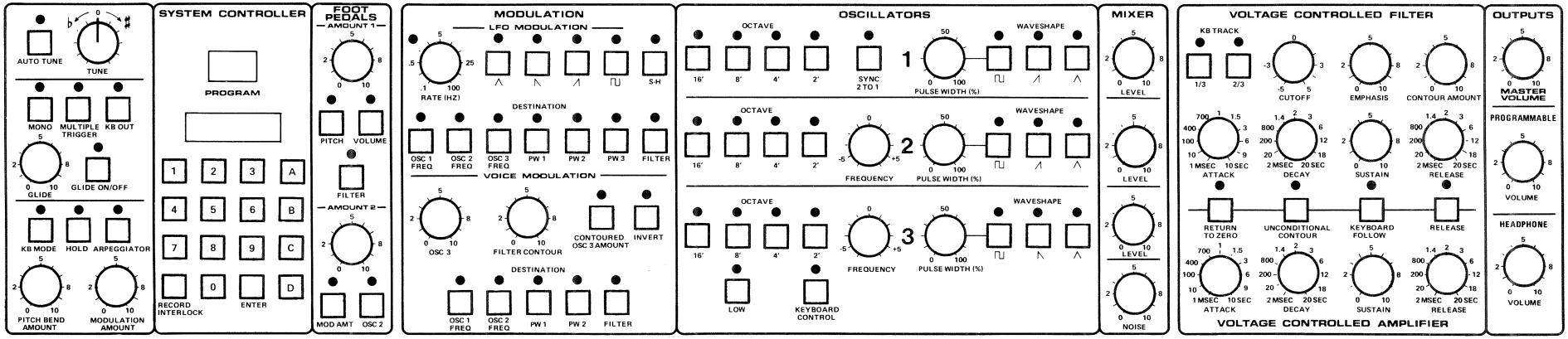
Using Pedal 1 to open up the Filter will enhance the Sustain segment of this program. Modulation (vibrato) is available from the Mod Wheel.



99. CLAV 5

For a chorus clav sound, turn on the rectangular waveshapes for Osc 2 and/or Osc 3. The Mod Wheel will introduce a tremolo effect.

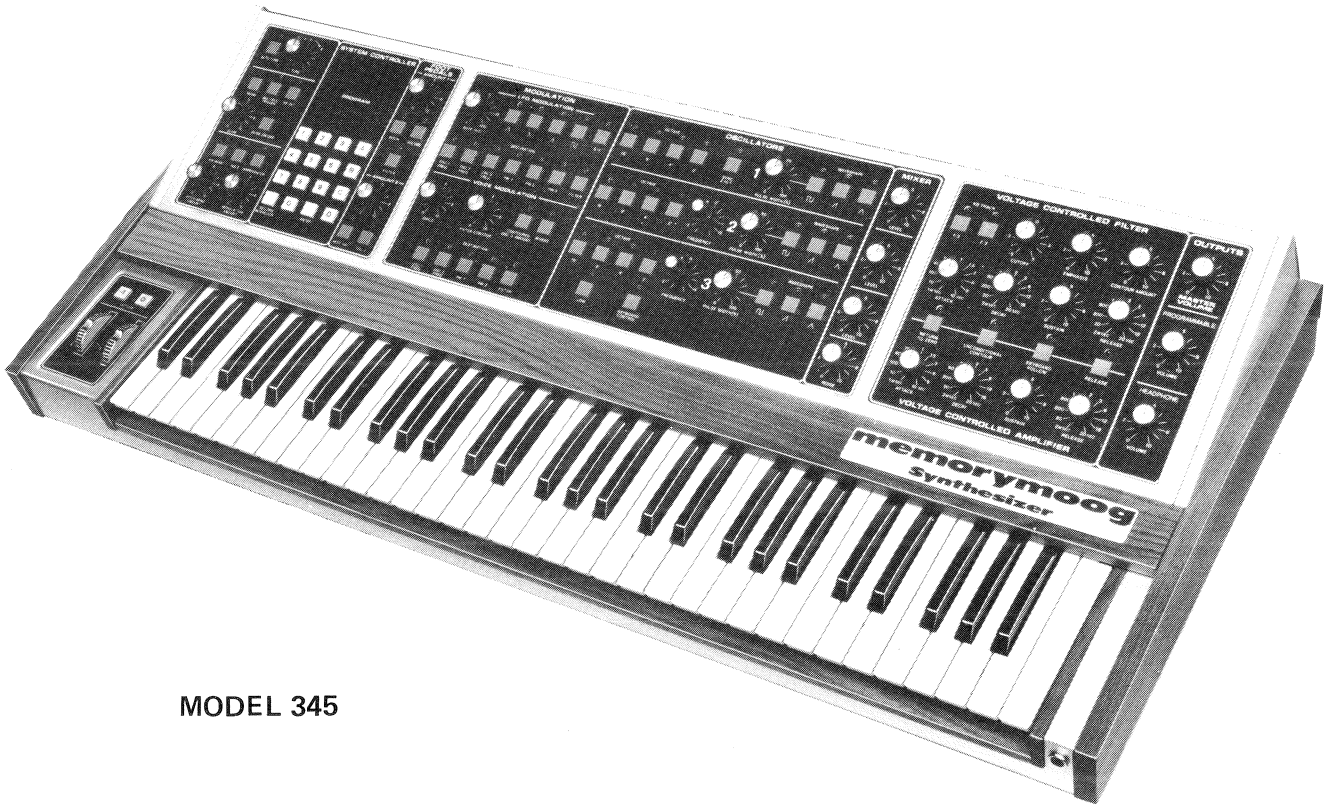




SECTION IV

TECHNICAL SERVICE INFORMATION for

MEMORYMOOG



MODEL 345

CAUTION

These servicing instructions are for use by qualified personnel only. To avoid risk of electric shock, do not perform any servicing other than that described in the Owner's Manual unless you are qualified to do so. Refer all servicing to qualified service personnel.

MOOG MUSIC INC.
2500 Walden Avenue, Buffalo, New York 14225

MOOG MUSIC
p/a Waalhaven Zuid Zijde 48, 3088 HJ, Rotterdam, The Netherlands

MUSIC INC.
2500 Walden Avenue
Buffalo, NY 14225 Phone (716) 681-7200

MEMORYMOOG OWNER'S MANUAL ADDENDA

SPECIAL ANNOUNCEMENT!

997-045924-901
February 1, 1983

All Memorymoogs now include a cassette of factory programs. This cassette is included in the white envelope along with your schematics, warranty card and service center list.

Page 6 - Under Section 1.9 (Arpeggiator), the following modes should be added:

7) Plays all notes simultaneously.
8) Plays back notes in order they are played, first-to-last-to-first.
9) Plays back notes in order they are played, first-to-last-to-first (latched).

Page 9 - Prefix C8, second line replace "powers up" with "was shipped".

Page 18 - Security Code - In the first paragraph, ninth line, add the phrase "followed by ENTER" after " the existing code".

Page 19 - A/B comparisons - In the third paragraph, the sixth line states that hitting the RECORD INTERLOCK switch will bring back the edited program, hit the ENTER instead. In the fourth paragraph, the fourth line says to use the RECORD INTERLOCK switch to go back and forth between the recorded program and the edited program. Again, to do this, use the ENTER switch.

Pages 40, 41, 42 - The line drawings show connections being made to the side of the 1120 Footpedal Controller. The connections should be made to the front of the Controller, as shown in the photograph on Page 48.

Page 46 - The diagram labeled "Contour Oscillator 3 Modulation" suggests that the Oscillator 3 amount control is used for contoured voice modulation, turn up the Filter Contour pot (be sure the CONTOURED OSC. 3 AMT. switch is on).

Page 50 - Your Memorymoog is programmed at the factory with 100 presets, program chains, etc. However, the Revision 6 factory preset tape mentioned above has a slight difference in the program chains. If this tape is loaded into the Memorymoog, update it as follows in order that the program chains correspond to those detailed on page 50:

1) Hit the "D" button. The alpha display will show "P".
2) Hit the "D" button again. The alpha display will show "L".
3) Hit 1, then "ENTER". The alpha display will show "L 1" and the program display will show "58".
4) Hit 1, then "ENTER" again. The program display will show "1".
5) Hit "A", the advance button repeatedly, until the program display shows "91".
6) Hit the "D" button to stop loading Program Chain 1.

All the program chains will now agree with the page 50 owner's manual information.

VENTILATION CLEARANCE - The Memorymoog has a built-in fan that exhausts hot air from the instrument. For optimum tuning stability, be sure that this fan is not obstructed in any way i.e., do not operate the Memorymoog if it is sitting on deep pile shag carpeting. Also, always make sure that the instrument is firmly seated on all four "feet"; if it rests on a board or surface that is too narrow, the board or surface may be flush against the fan outlet and heat may not be able to escape the instrument, resulting in tuning instability.

BEAT RATES - Several of the Memorymoog's factory program (such as numbers 13, 19, 35 and 47) incorporate a certain amount of detuning as an integral part of the sound. Tolerance variance from instsrument to instrument can change these beat rates slightly. If they sound incorrect, adjusts the frequency controls for Osc. 2 and/or Osc. 3. When the voice sounds right, store the new frequency setting as part of the program.

MEMORYMOOG SERVICE MANUAL

TABLE OF CONTENTS

SPECIAL NOTE:

* Indicates Input and/or Output is Active Low (BAR)

MEMORYMOOG SPECIFICATIONS AND FUNCTIONS

The Memorymoog is a versatile six-voice, programmable polyphonic synthesizer with the classic Moog sound, housed in an anodized aluminum cabinet trimmed with selected walnut.

All Memorymoog functions are under the control of a Z-80 micro-computer which continually monitors the soundpath, responding to all performer input through the keyboard, panel controls, foot pedals and system controller.

The front-panel settings are stored as a "program". The Memorymoog will remember 100 programs. These are stored and recalled by the system controller, which is used to access all special functions of the Memorymoog. In addition, 20 program chains - sets of 10 programs - can be stored and stepped through forward or back with footswitches for fast onstage voice changes.

Two programmable foot pedal inputs provide control of volume, pitch, filter cutoff frequency, modulation amount and sync sweep, allowing the performer to keep both hands on the keyboard. The routing and settings of these pedals are programmable.

Different keyboard modes may be selected through the system controller. The modes are: 1. CYCLIC - the first key played is sounded by voice A, the second key, voice B, etc. 2. CYCLIC WITH MEMORY: similar to #1 except that a repeated key will not be reassigned. 3. RESET: any single key will be assigned to voice A (this mode will behave like a monophonic keyboard on individual lines). 4. RESET WITH MEMORY - similar to #3, but with memory function described in #2.

In monophonic performance, the number of active voices (one to six) may be selected to be played in unison. The keyboard priority (low-note, high-note, or last-note-played) may also be selected.

Glide may be activated in either the monophonic or polyphonic modes of operation.

The Memorymoog operates in a continuous edit state; setting of any control may be instantly changed by moving that control.

When editing, the alphanumeric display shows both the memorized value of the control and the edited value.

All information stored in the Memorymoog may be saved on a standard cassette for later re-use.

KEYBOARD
C-C, 61 keys (5 octaves)

VOICES
The Memorymoog is a 6-voice instrument.
Each voice contains:
OSCILLATORS
3 Audio oscillators - range: 16', 8', 4', 2'. (Range is extended to 32' with transpose switch in performance area).
Waveforms available: variable pulse, sawtooth and triangular.
Oscillators 2 & 3 have dual concentric frequency pots; center knob for fine tune (12 turns), outer knob for coarse tune.
Sync Osc 2 to Osc 1.
Osc 3 acts as an audio or modulation oscillator. Osc 3 rate: .2 Hz to 8 KHz.

VOICE MODULATION
Osc 3 signal or filter contour may be routed to Osc 1, 2, pulse width 1, 2 and/or filter. Filter contour can control amount of Osc 3 modulation effect.

MIXER
Individual level controls for each oscillator and digital pink noise source.

MODULATION
LFO frequency - .1 Hz to 100 Hz.
Waveforms available: triangle, reverse sawtooth, sawtooth, square or sample & hold. Routing to Osc 1, 2, 3, pulse width 1, 2, 3 and/or filter.

VOLTAGE CONTROLLED FILTER
Moog 24 dB/octave filter. Filter keyboard tracking selectable 1/3, 2/3 or full.

CONTOUR GENERATORS
Two four-part (Attack, Decay, Sustain, Release) contour generators. Attack time: 10 seceonds maximum.
Decay & Release time: 20 seconds maximum.
Return-to-zero, unconditional contour and keyboard follow modes are selectable for the contours.

FOOTPEDALS
Two Moog 1120 footpedals can be connected. Pedal 1 controls pitch, volume & filter. Pedal 2 controls mod amount & Osc 2 pitch. Pedal assignment and sensitivity are stored as part of a program.

GLIDE
Type: Linear
Active in all monophonic and polyphonic modes. Glide modes are dependent on keyboard assignment modes.

SYSTEM CONTROLLER CODES
C0 - Sequentially flashing LEDs - a service routine
C1 - Cassette Save
C2 - Cassette Load
C3 - Cassette Verify
C4 - Defeats voices sequentially - a service routine
C5 - Frequency center for Osc 2 & 3 to Osc 1 (zero beats)
C6 - Tuning Calibration - defeats auto tune
C7 - Auto assigned tuning (for servicing)
C8 - Program enable and disable
C9 - live front panel (programming)
D0 - through D9 are program sequence codes
A - advance program chain
B - back step program chain

OUTPUTS
Programmable volume for program level balancing. Master output volume control. Headphone output level.

REAR PANEL
Balanced line (600 ohms) & high level (unbalanced 5K) outputs.
Footpedal in 1 & 2.
External synthesizer CV, gate and S-trig outputs (with range & scale trims).
Release, Hold, Program Advance and Program Back Step footswitch inputs.
External Clock input (to arpeggiator).
Cassette Interface.

POWER REQUIREMENTS
Domestic: 120-127 volts 50/60 Hz
Export: 200-254 volts 50/60 Hz

POWER CONSUMPTION
110 watts

DIMENSIONS & WEIGHT
Net weight: 38 lbs. (17Kg)
Overall size: 40" by 18-3/8" by 6-1/2"
101.6 cm by 46.7 cm by 16.5 cm

GENERAL

The MEMORYMOOG is a state-of-the-art six voice programmable synthesizer with a five octave keyboard designed in the tradition of the MINIMOOG.

SOUND
The design of the MEMORYMOOG is very similar to the MINI with three oscillators, two contour generators, MOOG 24db per octave filter and a voltage controlled amplifier. In addition, it includes other features to further improve the sound generation possibilities.
To the oscillators is added sync and variable pulse width. The contour generators were expanded to four parts with three modes of operation, including a mode where the attack, decay and release times track the keyboard for better simulation of acoustical instruments like the piano.

The voice card is further enhanced by two powerful modulation systems: LFO modulation and Voice modulation. The LFO modulator contains its own wide range oscillator and routing switches. The amount of modulation is controlled by the modulation wheel, a foot pedal or a fixed amount may be programmed. This modulation section controls all voices simultaneously and can be used to control pitch, pulse width or filter cutoff for vibrato and tremolo.

Voice modulation works on each individual voice card. The modulation signal for each voice comes from its own oscillator three and/or the filter contour. This generates independent modulation for each voice card. Voice modulation can also control pitch, pulse width and filter cutoff for chorus effects, sync sweeps and other musical effects.

PERFORMANCE ORIENTATION
Programming is made easier by first making almost everything programmable except for tune, final volume and headphone volume. Secondly, a full complement of knobs and switches have LED indicators. These first two features allow set-up of your personal programs just like a non-programmable monophonic synthesizer. Next, there are 100 locations where these programs can be stored. If 100 is not enough, included is a cassette interface so programs can be stored on an inexpensive audio cassette deck providing almost unlimited storage.

In addition to the above, a two-digit display tells what program is currently in use while a second eight-character alphanumeric display keeps the player informed of the instrument status. For example, it tells when the instrument is ready to play (after a short warm-up), when the autotune cycle is complete or when a loaded cassette is verified.
For program selection, one need only punch in a two-digit number on a keypad. This gives simple, reliable and fast program selection.

The MEMORYMOOG has 20 program sequence registers. In these registers one can load up to ten program numbers in any order and during performance sequence the programs with a foot switch. Lastly are programmable inputs for voltage foot pedals like the MOOG 1120. These foot pedals allow control of pitch, volume, modulation amount and filter cutoff.

ARPEGGIATOR
Unlike conventional arpeggiators that are limited to playing notes up and/or down the keyboard, the arpeggiator in the MEMORYMOOG is more like a micro sequencer in that it arpeggiates notes in the order depressed. The arpeggiator will then play them forward or forward and backward. This gives a variety of musical patterns limited only by imagination. The notes can be "latched" so the arpeggio will continue to play after key release. Notes in the pattern can be replaced in real time by adding new notes from the keyboard. The arpeggio can also be transposed from the keyboard over a five octave range.

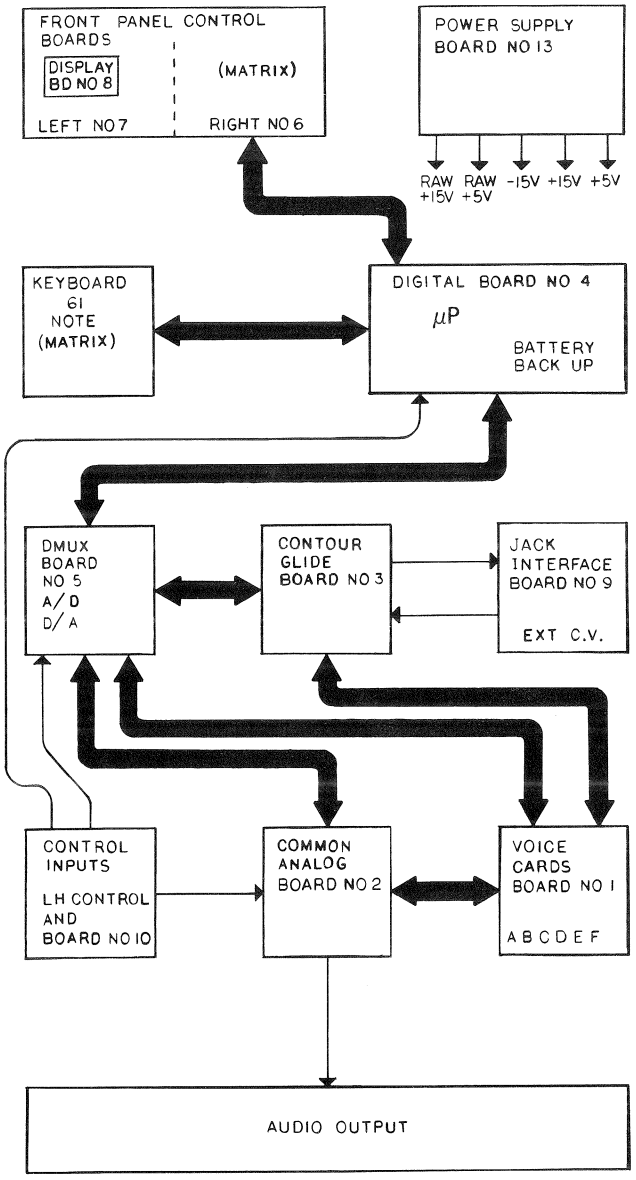
The arpeggiation rate is set by the LFO modulation oscillator and is therefore programmable. In addition, the modulation oscillator is reset when the first note on the keyboard is played to keep the arpeggiator in sync with the music.

The internal clock is supplemented by an external clock input for syncing the arpeggiator with an external device. The internal clock works fine for most applications until playing an arpeggio against something like a rhythm box. Then a problem arises because both have independent clocks. Even with careful adjustment of one against the other, a small error will still exist that will cause the two to slowly drift apart destroying timing. The external clock input gets around this problem since the clock output of the rhythm box drives the arpeggiator. The two systems then will work off the same time base and, therefore, remain in sync.

CIRCUITRY

The MEMORYMOOG is a six voice fully programmable analog synthesizer with all voicing parameters stored digitally. Interface with the synthesizer circuitry (VOICE CARDS) is accomplished with digital to analog conversion of this data and transmission to the appropriate circuit element via control inputs from the front and rear panel switches, potentiometers and keyboard. These functions are controlled by a Z80 microprocessor CPU on the DIGITAL board in response to program information stored in the system ROM. Refer to the accompanying block diagram.

All continuously variable functions are voltage controlled and all switching functions electronic. Data for voltage controlled functions is stored in random access memory (RAM), converted to an analog voltage by a D/A converter and routed to the correct control voltage port by a demultiplexer on the demultiplexer (DMUX) board. All front panel switches and rear panel inputs are either TTL compatible or are level translated to interface directly with the DIGITAL board.



BLOCK DIAGRAM

The DMUX board provides triggers for the CONTOUR/GLIDE board, output drives for the COMMON ANALOG board (bussed to the VOICE CARDS) and in addition, decodes front panel analog potentiometer settings into digital information using software generated successive approximations.

The CONTOUR/GLIDE board generates polyphonic and monophonic glide, a loudness contour and filter contour.

Particularly note that in the MEMORYMOOG, certain circuit elements are CRITICAL to the performance and operation of the circuit and should be checked for calibration and operation before ANY other adjustment or repair is attempted. In order of priority, here is a list of parameters to be checked and ADJUSTED ONLY IF ABSOLUTELY REQUIRED:

1. The +15V, -15V & +5V power supplies on the POWER SUPPLY board are measured on DMUX board. (See power supply section.)

2. The +10V DAC reference supply (DAC ZERO and FULL SCALE) on the DMUX board.

POWER SUPPLY

The power supply includes a printed circuit board assembly, fan, heat sink, split primary transformer and a bottom mounted plate that converts 100/120 to 220/240 Volts. The plates include a connector and all the appropriate fuses including secondary fuses. Regulation is accomplished with 723 regulators, MPSU05 drivers and a series of TIP41 pass transistors. There is a raw 5V tap which feeds the FRONT PANEL LEDs and a tap of the +15V supply for the power shutdown circuit on the DIGITAL board. The power supply has remote sense lines which are wired to the DMUX board. Each of the three independent output windings of T1 is applied to a full wave bridge rectifier and regulator circuit to provide regulated -15, +15 and +5 VDC outputs. The output of each bridge rectifier is filtered by an electrolytic capacitor having a bleeder resistor connected in parallel to remove any residual charge when power is removed from the unit.

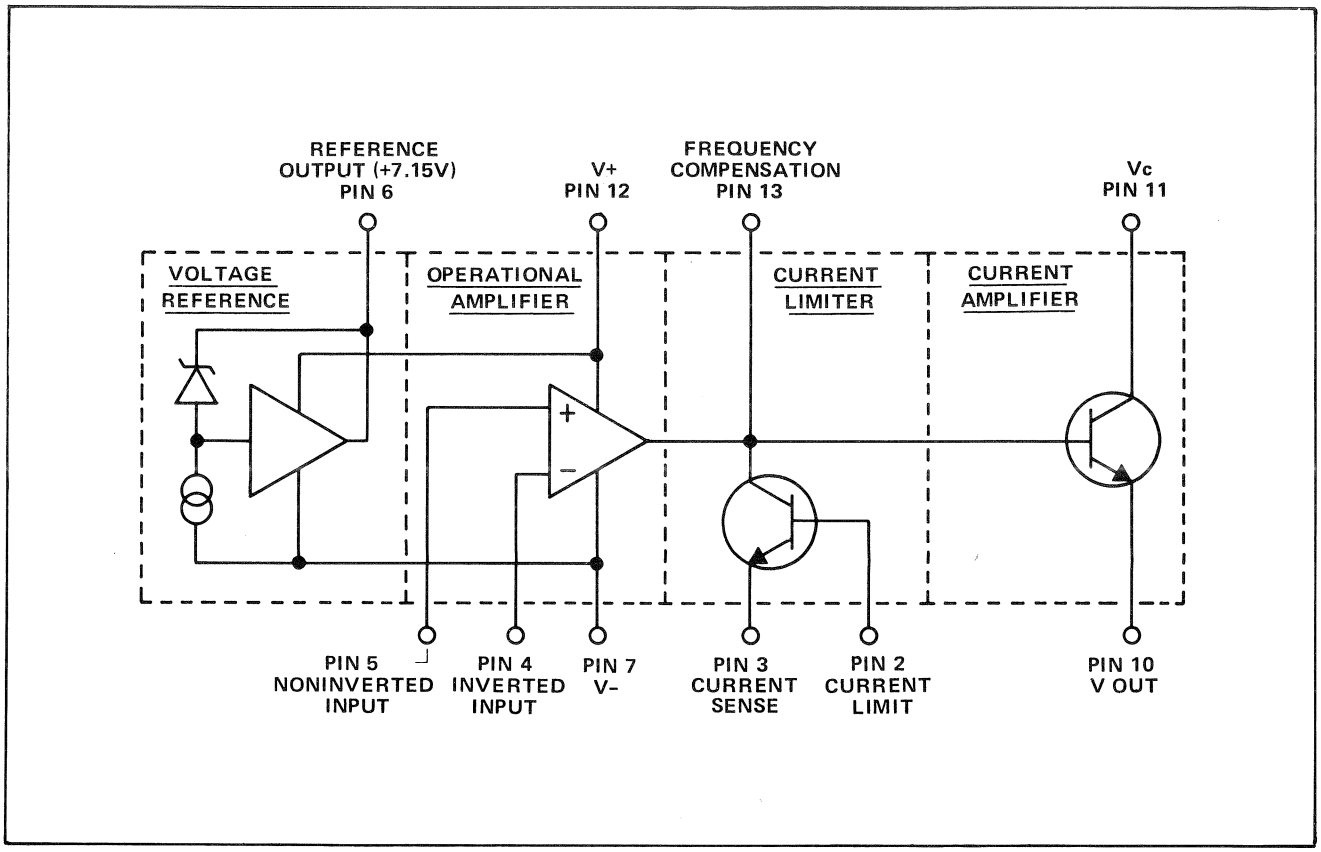
The heart of each regulator section is comprised of a 723 integrated circuit consisting of four basic sections: a temperature compensated voltage reference, operational amplifier, current limiter and current amplifier. The voltage reference section of the +15 and +5 VDC supplies produces a stable +7.15 +/- 0.36 VDC output at pin 6 which may be used at that level or divided down. The operational amplifier section is used as a linear amplifier to compare a direct or divided down reference voltage applied to pin 5 with a divided down sample of the power supply output voltage applied to pin 4.

The current amplifier section amplifies the small current obtained from the output of the operational amplifier section and is used as an emitter follower to drive external transistors from pin 10. The current limiter section, when connected to external circuitry, acts to limit or reduce the current available to the current amplifier section should a power supply current overload occur.

The output from each bridge rectifier and filter is a considerably higher voltage than the regulated output voltage. Transistors Q1, Q3, Q5 and Q6 are emitter followers acting as electronically variable resistors controlled by the current applied to their bases.

Transistors Q2, Q4 and Q7 operate as current amplifiers driving Q1, Q3, Q5 and Q6. The +7.15 VDC voltage reference from pin 6 of the 723 IC is applied to pin 5 (through a divider resistor on the +5 VDC supply) which is the noninverting input to the operational amplifier section of the IC. A voltage divider between the positive sensing terminal and the negative sensing terminal applies a voltage proportional to the output voltage into the inverting input (pin 4) of the operational amplifier to be compared with the reference voltage applied to pin 5. If the output voltage is too high, the voltage at pin 4 will be higher than the voltage at pin 5. This reduces the current into the base of the driver transistor in turn reducing the current into the base of the pass transistor causing the output voltage to drop to the correct level. If the output voltage is too low, the opposite action occurs.

The two types of overcurrent protection provided include a constant current overload protection used on the + and -15 volt output. On the + and -15 volt outputs, resistors R6 and R17 are in series with the output. The current limit transistor in the 723 IC is connected to this resistor so that if the voltage drop of this resistor exceeds 0.6 volt due to excessive output current, this transistor conducts to prevent any further increase in the output current. When this point is reached, the output voltage will start to drop. The foldback overload protection used in the +5 volt section of the power supply operates by sensing both voltage and current. An overload is first sensed by the combined drop across the base-emitter junction of Q5 and the drop across R31. When the combined drop exceeds approximately 1.2 volts, the current limit transistor in the IC starts to conduct causing the output voltage to begin to drop. When this happens, the voltage drop across the divider becomes less causing the current limit to conduct even more. As a result of this regenerative action, the short circuited current of the power supply is much less than the rated full load current.

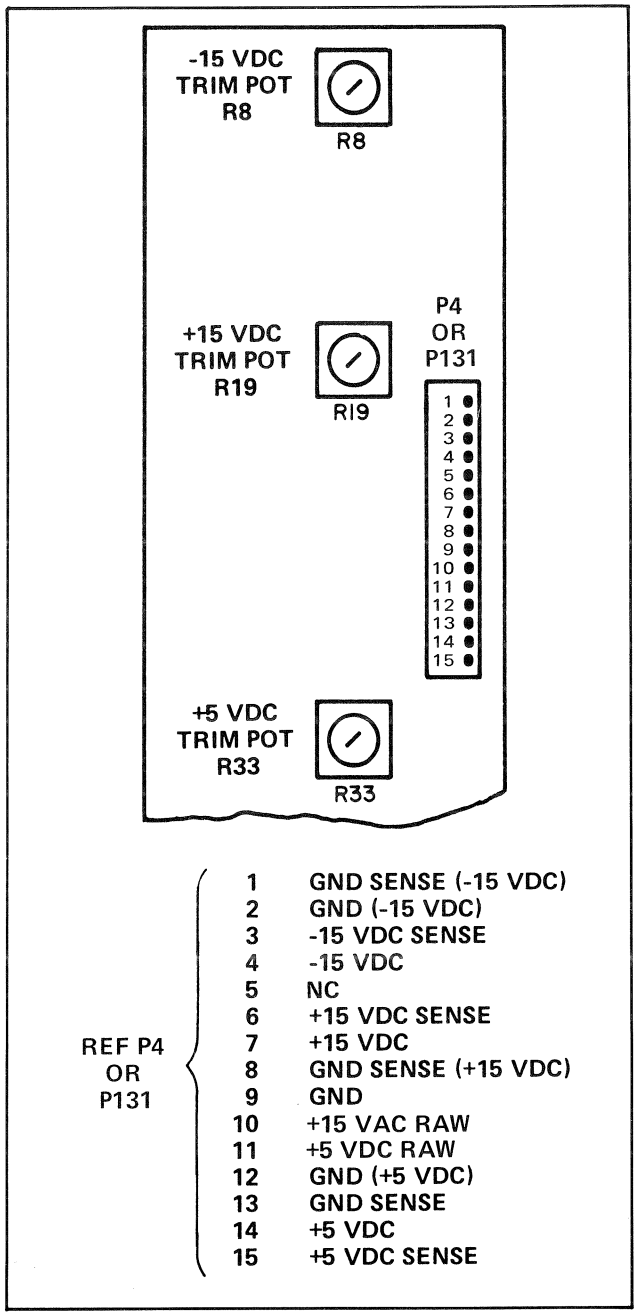


VOLTAGE REGULATOR INTEGRATED CIRCUIT (723 DIP PACKAGE)

POWER SUPPLY (CONT'D)

Variable resistors R8, R19 and R33 allow for individual adjustment of each output voltage. Resistors R10, R21 and R35 and diodes CR6 and CR13 prevent the outputs from rising to excessive levels should one of the sensing leads accidentally become disconnected. Diodes CR7, CR14 and CR20 across each output protect its output from accidental application of a reversed voltage to its output terminals. Capacitors C3, C6 and C9 provide a low dynamic impedance for each output.

Refer to the accompanying power supply diagrams and schematics .



POWER SUPPLY ASSEMBLY ADJUSTMENT CONTROLS AND OUTPUTS

DIGITAL BOARD

The CPU is at the left center of the DIGITAL BOARD schematic along with three program EPROMs and room for four 2K x 8 RAMs of which three are used. These are CMOS battery backed-up RAMs. As each instruction is fetched from memory, it is placed in the instruction register and decoded. The control sections perform this function and then generate and supply all of the control signals necessary to READ or WRITE data from or to the registers, control the arithmetic logic unit and provide all required external control signals.

The Z80 CPU contains 208 bits of R/W (READ/WRITE) memory that are accessible to the programmer which is configured into eighteen 8 bit registers and four 16 bit registers. All Z80 registers are implemented using static RAM. The registers include two sets of six general purpose registers that may be used individually as 8 bit registers or in pairs as 16 bit registers. There are also two sets of accumulator and flag registers.

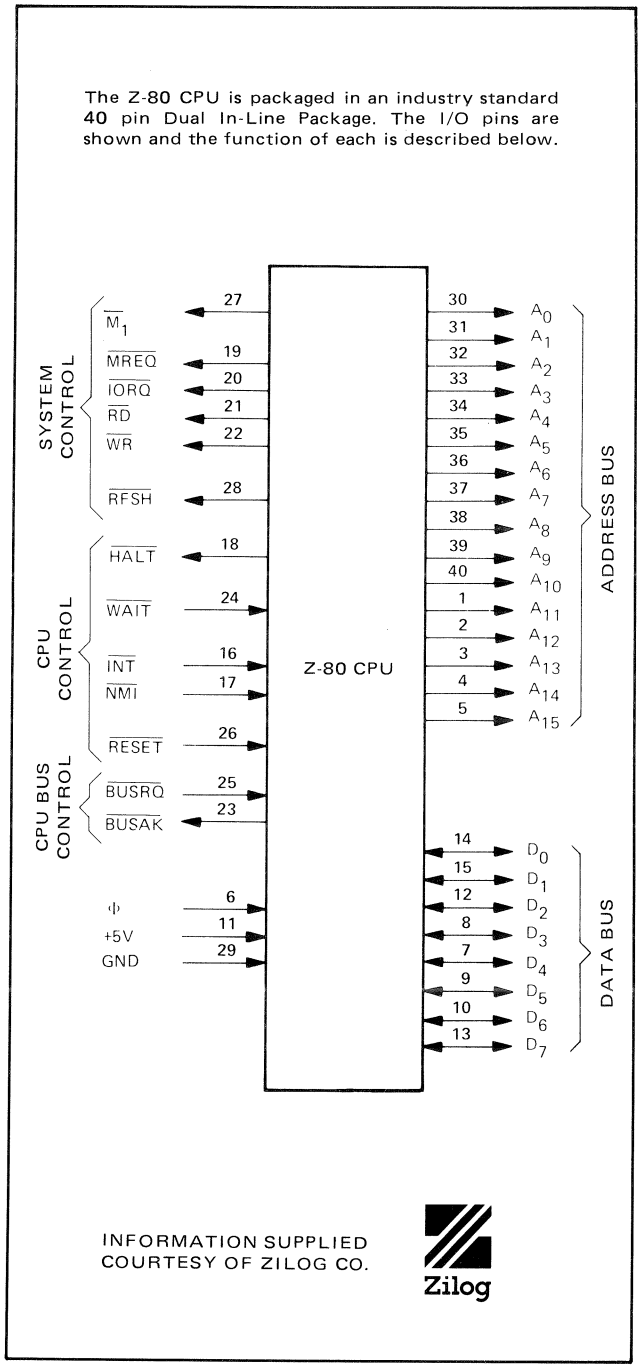
A PROGRAM COUNTER (PC) is a special purpose register that holds the 16 bit address of current instruction being fetched from memory. The PC is automatically incremented after its contents have been transferred to the address lines. When a program jump occurs the new value is automatically placed into PC, overriding the incrementer. The STACK POINTER (SP), another special purpose resistor, holds the 16 bit address of the current top of a stack located anywhere in external RAM memory. The external stack memory is organized as a last in first out (LIFO) file. Data can be pushed onto the stack from specific CPU registers or popped off the stack into specific CPU registers through the execution of PUSH and POP instructions. The data popped from the stack is always the last data pushed onto it. Two independent special purpose INDEX REGISTERS (IX & IY) hold a 16 bit base address that is used in indexed addressing modes. In this mode, an index register is used as a base point to a region in memory from which data is to be stored or retrieved. An additional byte is included in the instructions to specify a displacement from this base. The INTERRUPT PAGE ADDRESS REGISTER (I) is not used in the MEMORYMOOG and the MEMORY REFRESH REGISTER is also not used in the MEMORYMOOG.

The CPU includes two 8 bit ACCUMULATORS and associated 8 bit FLAG registers. The ACCUMULATOR holds the results of 8 bit arithmetic or logical operations while the FLAG register indicates specific conditions for 8 bit or 16 bit operations, such as indicating whether or not the result of an operation is equal to zero.

There are two matched sets of GENERAL PURPOSE REGISTERS, each set containing six 8 bit registers that may be used

individually, as 8 bit registers or 16 bit register pairs. One set is called BC, DE, and HL while the complementary or alternate set is called BC', DE', and HL' and finally there is the ARITHMETIC LOGIC UNIT which has 8 bit ARITHMETIC and LOGICAL INSTRUCTIONS of the CPU which are executed in the ALU. Internally the ALU communicates with the registers and the external data bus and the internal bus.

Listed below are the Z80 CPU pin descriptions which are the functional designations for the pinout of the CPU. Refer to the accompanying figure for the corresponding pin number.



Z-80 CPU PIN DESCRIPTION

A0-A15 (address bus)
Tri-state output, active high. The address bus provides the address for memory (up to 64K bytes), data exchanges and for I/O device data exchanges. I/O addressing uses the 8 lower address bits to allow the user to directly select up to 256 input or 256 output ports. A0 is the least significant address bit.

D0-D7 (data bus)
Tri-state input/output, active high. The data bus is used for data exchange with memory and I/O devices.

MREQ* (memory request)
Tri-state output, active low. The memory request signal indicates that the address bus holds a valid address for a memory READ or WRITE operation.

IORQ* (input/output request)
Tri-state output, active low. The IORQ* signal indicates that the lower half of the address bus holds a valid address for an I/O READ or WRITE operation.

RD* (memory read)
Tri-state output, active low. RD* indicates that the CPU wants to READ data from memory or an I/O device.

WR* (memory write)
Tri-state output, active low. WR* indicates that the CPU data bus holds valid data to be stored in the addressed memory or I/O device.

WAIT* (wait)
Input, active low. WAIT* indicates to the CPU that the addressed memory or I/O devices are not ready for data transfer. The CPU continues to enter wait states for as long as this signal is active. This signal allows memory or I/O devices of any speed to be synchronized to the CPU.

INT* (interrupt request)
Input, active low. The Interrupt Request signal is generated by I/O devices. A request will be honored at the end of the current instruction fetch if the internal software controlled interrupt enable flip-flop (IFF) is enabled.

M1* (Machine Cycle One)
Output, Active low. M1* indicates that the current machine cycle occurs with IORQ* to indicate an interrupt acknowledge cycle.

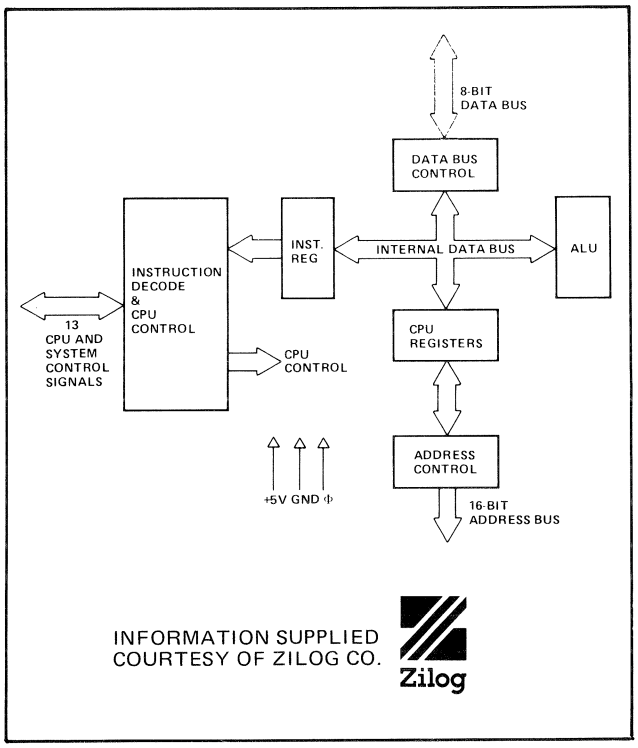
RESET*
Input, active low. RESET* forces the program counter to zero and initializes the CPU.

I (clock)
Single phase TTL level clock.

CLOCK CIRCUITRY
Clock inverter U14, crystal Y1, resistors R10, R11 capacitors C8 and C6 form a 4 megahertz oscillator that drives flip-flop U16. The flip-flop is connected as a divide by two circuit to insure that the waveform will be a square wave at the required frequency of two megahertz.

DIGITAL BOARD (CONT'D)

Resistor R12 provides the necessary pull up for the processor. The RESET circuit consists of diode CR1, resistor R9, capacitor C5 and inverters U15 and U14. When power is initially applied, the output of U14 will be at ground which holds the CPU in a RESET* state and capacitor C5 will begin to charge through resistor R9. When the voltage on C5 reaches the threshold of CMOS Schmitt trigger U15 (in approximately 1.5 sec), the output of U14 will go high removing the RESET* condition. The CPU will now run the power-up software. CR1 insures that momentary power outages will dump the charge on C5 and revert to the RESET* state. A Z80 CTC counter/timer is used in conjunction with the Z80 CPU to provide realtime functions and future interfacing capabilities. Its operation will be discussed in detail throughout the text.



Z-80 CPU BLOCK DIAGRAM

DMUX WAIT STATE GENERATOR

All data written to the Digital to Analog Converter (DAC) is done with OUTPUT instructions. To allow the DAC time to settle and the sample and hold capacitors time to charge up, WAIT states are introduced into all OUTPUT instructions below 80 hex. The WAIT state generator consists of U31, a dual four-bit counter cascaded to form an eight bit counter, a D-type flip-flop U33 and some associated gates.

As a starting point, assume the next instruction the CPU will execute is an OUTPUT instruction, then the logic states of the WAIT state circuitry will be as follows: The RESET pins, R1 and R2 of U31 will be at a logical 1, which is the RESET state and therefore, all the U31 outputs will be 0. The flip-flop U33, Q* output will be a logical 0 and the WAIT* line at a logical one, which is off.

When the OUTPUT instruction is executed, the CPU IORQ* line goes low, the A7 line will be low and the M1 line remains high. This will cause the U13 pin 3 output to go low, removing the RESET from counter U31. Pin 8 of U12 will be low sending its output high, which is inverted by U12, turning the WAIT* line on or low. Also, flip-flop U33 is clocked via inverter U14, sending its Q* output high. The action of flip-flop U33's output going high disables address decoder U34, forcing all of its outputs high, disabling all DMUX channels.

In this state, the OUTPUT instruction will be extended until the WAIT* line returns high.

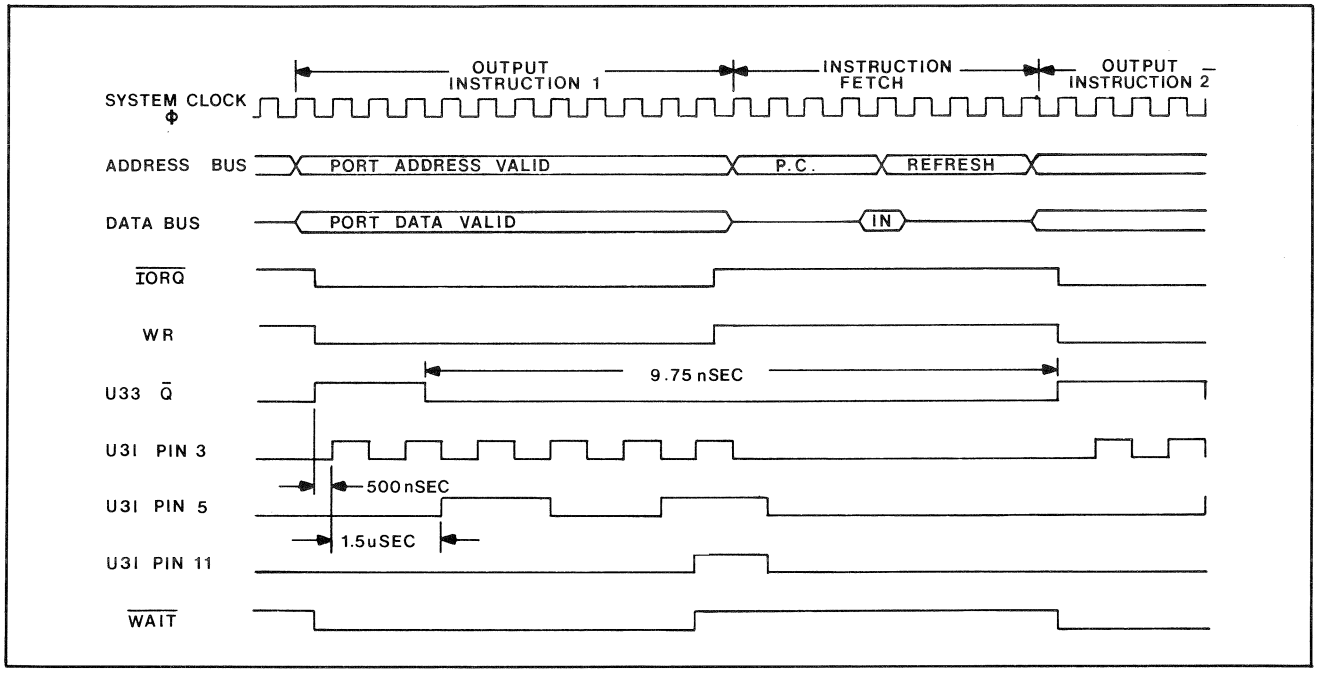
Since the RESET has been removed from U31, it is now free to be clocked by the system clock. On the first rising edge of the system clock after the IORQ* has gone low, U31's Q0 output, pin 3, will go high clocking the 8-bit address latch U32 and clocking the DAC latch on the DMUX board via the D CLK line of connector S43 pin 9.

So far we have turned on the WAIT* line, inhibited all DMUX channels (on the DMUX board) and latched both address and data busses.

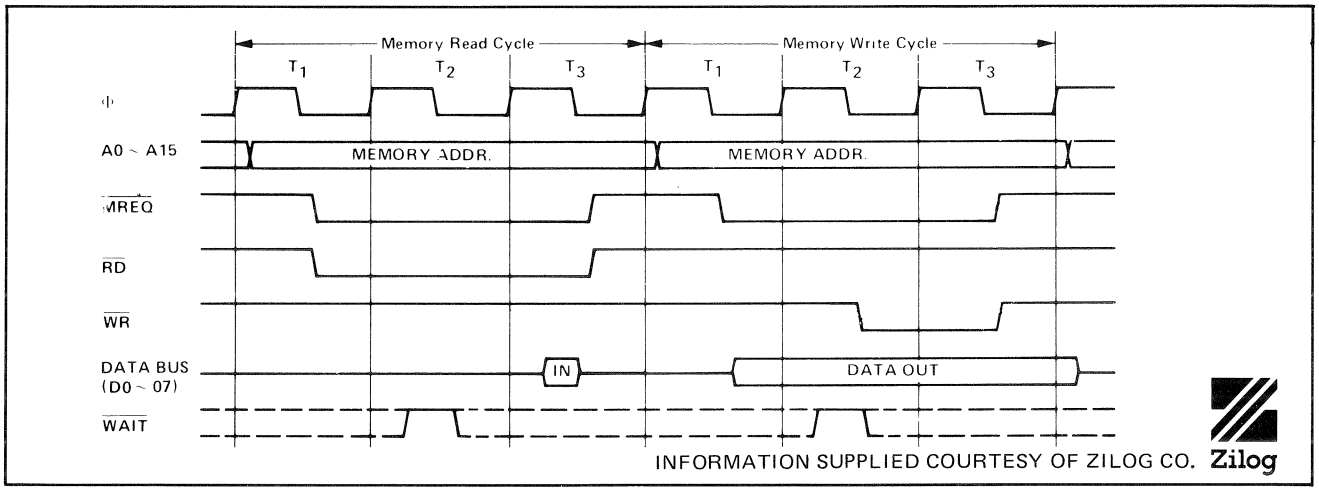
Continuing the OUTPUT instruction cycle three system clock cycles later, the U31 Q2 output, pin 5, goes high which, via inverter U21, applies a SET to flip-flop U33 forcing its Q* output low. This enables the address decoder U34, enabling the selected 4051 IC on the DMUX board. The appropriate sample and hold capacitor, also on the DMUX board, will now charge up (or discharge) to its new output value and the channel will remain on until the next OUTPUT instruction is executed.

The instruction ends after 12 more system clock cycles, when the Q0 output, pin 11, of U31 goes high sending the WAIT* line high (off) and the RESET condition is again applied to U31.

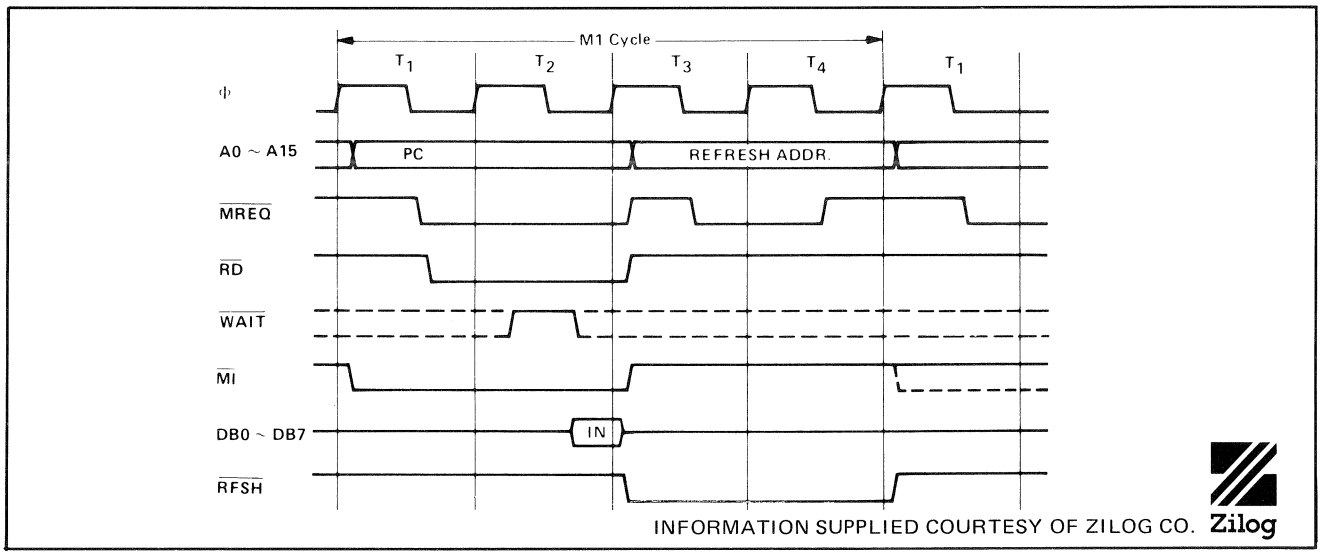
Note that address decoder U35, which is used to drive the multiplexer (MUX), operates similarly to the DMUX address decoder U34 but does not use the turn-on delay from U33. Since the multiplexer does not multiplex the DAC output but rather front panel potentiometer wiper voltages, there is no settling time associated with it. Also, note that the latched A6 line from the U32 latch output does not drive U35. Therefore, its decoded output will "fold over" on 40 hex boundaries instead of the 80 hex boundaries for the DMUX outputs. In other words, port 00 hex can also be addressed by addressing 40 hex.



WAIT STATE GENERATOR

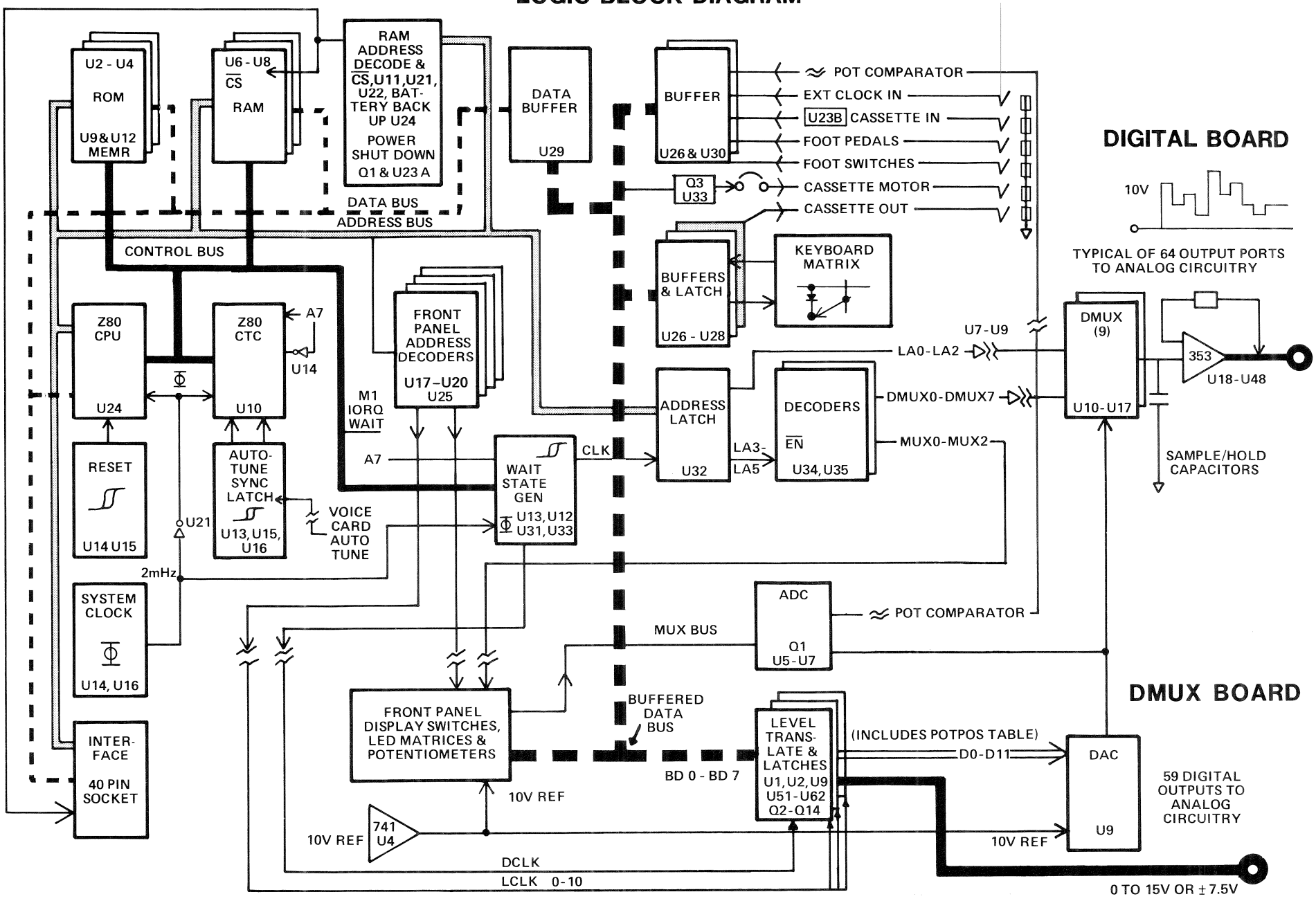


MEMORY READ OR WRITE CYCLES



INSTRUCTION OP CODE FETCH

LOGIC BLOCK DIAGRAM



FRONT PANEL AND KEYBOARD CIRCUITS

In the central portion of the schematic are ICs U17-20 which are 74LS138 address decoders. These handle the various memory mapped ports for the FRONT PANEL controls and switches using straight forward address decoding.

The keyboard circuit is in the upper right hand corner of the schematic and uses latches U26, U27 and U28. U26 and U27 are CMOS hex tri-state buffers divided into a section which uses six buffers and a section which uses two buffers each with a separate enable. All six buffers of U27 are used in conjunction with two buffers of U26 to form an eight bit buffer. This eight bit buffer and latch U28 are connected to the keyboard which is wired in a column and row matrix with a diode in series with each key.

Keyboard decoding is accomplished by WRITING all "zeros" to latch U28 and then reading the U26/U27 buffer output. Since the inputs (keyboard side) of the buffers have pull-up resistors, R28-R35, no keys down will result in all "ones" being READ. If this is the case, no further decoding is necesary, however, if other than all "ones" is READ at least one key is down and the keyboard must be fully decoded. This is done by WRITING data to latch U28 that will set one selected row low while all other rows are high and then reading the column data at buffer U26/U27. Whenever data other than all "ones" is READ from the buffer, in the row where the "zero" was WRITTEN, this indicates that one or more keys are down, therefore the column must be decoded. Columns are decoded by shifting the byte that was READ from the buffer. After the first row has been decoded the next row (starting from 00 and moving towards 07) is set to "zero" and all other rows will be high or "ones". This operation continues until all 8 rows have been decoded. If there are several notes played polyphonically, the diodes across each note prevent shorting of columns to columns and rows to rows. The priority structure scans down and across to find closures and scans progressively from memory, decoding up to a maximum of ten notes.

BATTERY BACKUP

RAM battery backup is accomplished by a 78MO5C 5-volt regulator that is used to generate a 5.6 volt supply for the RAMs. A 5.6 volt supply voltage is obtained by using a diode drop in the common leg of the regulator to ground which biases the common to +0.6V. The diode in series with the output drops it back down so at the junction of the three diodes, CR4, CR5 and CR6, the VRAM supply ends up at approximately 5 volts again under normal circumstances. A lithium battery voltage source provided through diode CR6 supplies power to the RAMs when the VCC supply drops. When power is lost, the RAMs can be damaged if the input voltages to the RAMs are still at or near 5 volts while the VRAM supply has dropped to the 2 or 3 volt battery level. To prevent this, the diode CR8, resistor R23 and capacitor C14 on the input, hold the non-battery VRAM supply up longer than the VCC. Thereby, VRAM only drops to the battery voltage after VCC has dropped below it.

POWER SHUT-DOWN CIRCUIT

Just below the battery backup circuit is the power shut-down circuit, consisting of U23A, Q1 and associated components. CR2 is connected, through harnessing, to the power supply transformer secondary ahead of the main filter capacitor on the +15V supply. The raw AC voltage is half wave rectified by CR2, filtered by C11, R18 and R19 and clamped from going above +5V by CR3. This results in a half-wave rectified waveform clipped at +5V with a rise time following the line voltage and an extended fall time. The fall time is extended enough so that the voltage level under normal circumstances will not fall below the threshold of +1V, set by R20 and R21, on pin 2 of U23A. When power does go down, even briefly, the lack of input to CR2 will cause pin 3 of U23A to fall below the threshold sending its output to zero, dumping the charge on C10 and turning on Q1, which disables the RAMS via gate pack U22. The filter capacitors in the power supply are large enough to hold the supplies up for 15-20 milliseconds. Restoring power will allow the U23A output to go high again, but since it has an open collector output, its only pull-up is R15, therefore, Q1 will remain on until C10 can charge up. This delay insures that the power supplies will be stabilized before the RAMS are enabled.

CTC COUNTER/TIMER

The Z80 CTC contains four eight-bit, programmable down-counters. It is I/O mapped between 80H-83H and used for the front panel LED multiplexing, AUTOTUNE and CASSETTE I/O routines, generally all the real time functions. One channel is used as a counter that is programmed to generate interrupts at every 1.25 millisecond intervals. These interrupts suspend the main system program loop to service the front panel DISPLAY and LED multiplexer routine.

INTERFACE JACKS

The FOOT SWITCH and FOOT PEDAL interface buffer is U30 at the central right-hand portion of the schematic. This CMOS hex tri-state buffer handles the FOOT PEDAL single bit inputs such that the processor can treat them as memory locations. It monitors J7, J8, J9 and J10, the RELEASE, HOLD, PROGRAM ADVANCE and PROGRAM BACKSTEP jacks and the two FOOT PEDAL controller input jacks J2 and J3. Pullup resistors set U30 high such that a switch closure to ground READS in either a zero or one for a specific bit. The CASSETTE I/O jacks J14, J15 and J16 are mapped similarly. The single bit input from J2 and J3 is used to prevent a possible operational trap that would occur if the FOOT PEDAL VOLUME was programmed ON from the FRONT PANEL and no FOOT PEDAL was plugged into either J2 or J3, causing the instrument output

INTERFACE JACKS (CONT'D)

volume to be zero. Nothing plugged into J2 or J3 will cause the system to disregard the FRONT PANEL programming and turn the FOOT PEDAL VOLUME off. The MODULATION OSCILLATOR'S SQUARE WAVE output is routed through the normally closed switch on jack J11 to level translator Q2. The MODULATION OSCILLATOR is applied to the data buss by buffer U26 and used as a time base for the ARPEGGIATOR. The MODULATION OSCILLATOR can be replaced as a time base by supplying an external clock to J11.

The CASSETTE OUTPUT uses the Q0 bit output from the keyboard circuit latch U28. This would seem to create a conflict between the two circuits but since the CASSETTE I/O routines suspend all other operations during their execution, this problem does not occur. The cassette transport on/off control circuit consists of flip-flop U33, Q3 and the relay. WRITING a "one" to bit D0 at the address mapped by U18, latches a "zero" at the U33 output, turns off Q2 and energizes the relay, turning on the tape transport. Similarly, writing a "zero" will turn the tape transport off. Diode CR9 shunts the back EMF developed by the relay coils, collapsing the field during turn-off which could otherwise damage Q2. The cassette output from the tape recorder is input via R45 and C19 to the inverting input of comparator U23B which is biased at +2.5V by resistor R43 and R44. The threshold on the non-inverting input of U23B is +2.5V or set by R41 and R42 with +/-120 mV of hysteresis determined by R40. Cassette data from the output of U23B is applied via buffer U26 to the data buss where it can be READ by the CPU. One of the CTC channels is used in conjunction with the cassette load routine to provide the time measurement necessary to determine "zero" or "one" data in.

AUTOTUNE

The AUTOTUNE circuit uses two channels of the CTC chip, flip-flop U16 and one section each of U13 and U15. By selective voice triggering and manipulating oscillator levels, any one of the eighteen audio oscillators can be applied to the pin 1 input of Schmitt trigger U15. After each oscillator's uncompensated frequency has been measured,the AUTOTUNE compensation value is calculated. It is then output via the DAC and DMUX to the corresponding oscillator summing node. One channel of the CTC is programmed as a "timer" and the other as a "counter". Channel three is the "timer" and is clocked by the 2mHz system clock, through a divide by 16 circuit which prescales it in the CTC, yielding an internal clock period of 8uSec. Timing begins when the CTC receives a positive edge on its pin 20 the CLK/TRG3 input. Channel two is the "counter" and counts negative edges at its pin 21 CLK/TRG2 input. Using these two channels results in a method of measuring "time"and "counting" oscillator cycles. Flip-flop U16 and gate U13 allow the timer and counter channels to be started synchronously by the falling edge of the oscillator under test. The pin 10 SET input of U16 is connected to memory mapped latch U28 so that the flip-flop can be held in its SET state until the AUTOTUNE routine is ready to make a frequency measurement. Upon removal of the SET from the flip-flop the next falling edge of the output goes to a "one", starting the channel three CTC timer and enabling gate U13. The oscillator will now appear at the pin 6 U13 output to be counted by the channel two CTC counter.

FUTURE EXPANSION

At the center of the schematic is an extra 40 pin DIP socket in which extra ROM, RAM or other hardware could be added in the future. These ports could latch data into the DAC for an appropriate use.

DEMULTIPLEXER BOARD #5

The purpose of the demultiplexer is to convert the serial current pulses from the DIGITAL board to parallel voltage outputs to drive the analog circuitry.

Analog data, specifically from the DAC, consists of serial current pulses with a variable magnitude of 0 to 3.32 mA. These current pulses are converted to a serial voltage pulse stream with a directly proportional magnitude between 0 and 10V, by U5. Capacitor C5 damps U5 to minimize overshoot and ringing. Also note the DAC will constantly convert its buffered data lines to analog current, sending it to the DEMULTIPLEXER. Valid information is separated by inhibiting the 4051 demultiplexer during times when invalid data is present at the DAC output.

Referring to left hand portion of the DMUX BOARD schematic, U10 through U17 are digitally controlled analog switches, each of which functions as an 8 pole single throw electronic switch. One of these devices is selected using the inhibit inputs DMUX0 through DMUX7 on pin 6 which is controlled from the DMUX driver circuit on the DIGITAL board via level translators U7 through U9. Each device is driven by address lines LA0, LA1 & LA2 from the CPU on the DIGITAL BOARD, via the level translators of U7. These three address lines will select which of the 4051's eight outputs is connected to the input.

By using the three address and eight inhibit lines a connection is made from the output of U5 to 1 of the 64 sample and hold buffers. Since the CPU synchronizes the address changes with the serial analog output of the DAC, analog data will be channeled via the DEMULTIPLEXER to its respective port.

Op Amps U18-U48 are connected as buffers and capacitors C7-70 form the sample & hold ports. The timing of the demultiplex operation is accomplished by: addressing an input port using LA0-LA2; data output through the DAC and U2B; a 4uS enable delay; one of the demultiplexer chips outputing a specific voltage; a 12 microseconds "on" time; and the operation

ending with the next port addressed and repeating the operation. Before any of the demultiplexer chips are turned "on", the 4uS delay allows time for the DAC to make its conversion and for some settling time for U2B. The 12 microseconds "on" period allows sufficient time to charge the holding capacitors for worst case conditions.

When a demultiplexer port is accesssed, the corresponding capacitor on the output will charge (or discharge) to the voltage that is output during the 12 uS "on" time. When the output is turned off, the capacitor holds the charge voltage until it is refreshed by the next "scan" through the demultiplexer routine. Since the input impedance of the buffer is extremely high, very little leakage or charge drain off from the capacitor will occur. Therefore, it will stay virtually at the voltage it was initially charged to between "scans".

SAMPLE/HOLD CIRCUIT

The series of 4051 demultiplexer ICs act like a giant commutator, in which the LA0, LA1 and LA2 lower order latched address lines are bussed together with specific chip selection accomplished by the appropriate inhibit lines. From the earlier text, remember that on the DIGITAL BOARD, the address decoding is accomplished on the three higher order address lines - A4, A5 and A6, resulting in the DMUX0-DMUX7 lines. Since the 4051s are operated between ground and +15V, their address lines are level translated from TTL to +15V by open collector buffers U7, U8 and U9. Each 4051 is followed by a 353 BIFET op amp buffer such as U18A and a sample/hold capacitor such as C7. For neatness, only two circuit configurations are shown on the top and bottom of the schematic and the remaining 62 are noted only in rectangular boxes. Below the DAC is U6B, a 393 comparator and a 2N3906 transistor Q1 which form a hysteresis circuit.

10V DAC REFERENCE

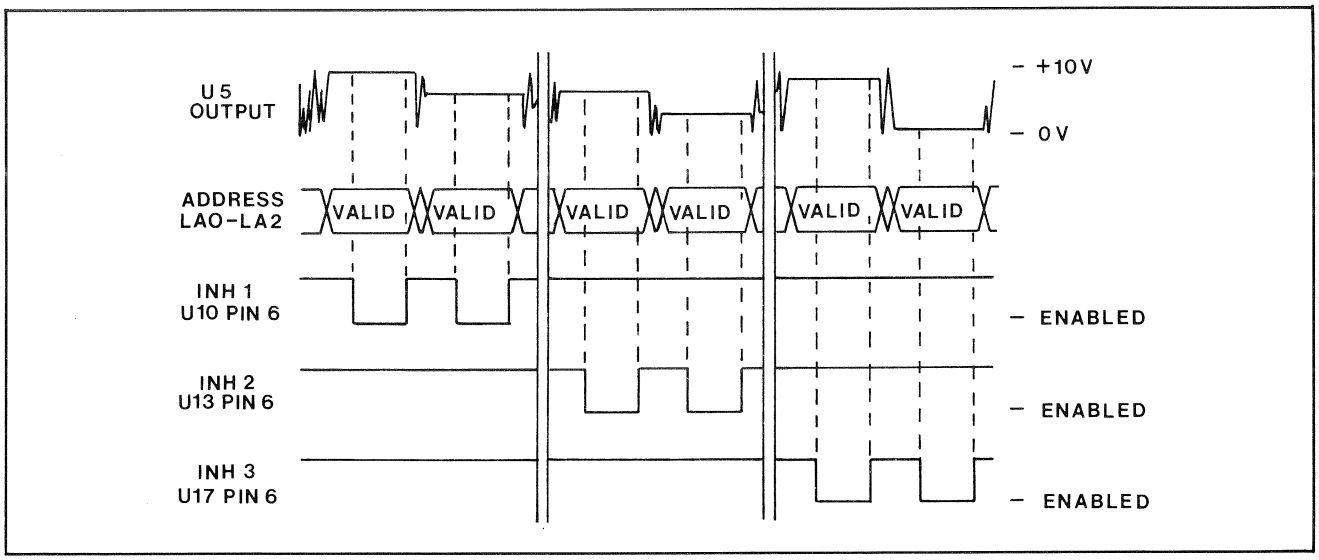
Looking at the upper left hand portion of the schematic, the DMUX BOARD has a 10 volt temperature compensated DAC reference voltage source. It is used for all the analog linear data and consists of zener diode CR1 and 741 buffer U4.

DAC CIRCUITRY

All digital to analog and analog to digital conversion is done using the 12-bit DAC U3, 8-bit data latch U2, 6-bit data latch U1, current to voltage converter U5 and successive approximation comparator U6A. C2 and C4 are supply decoupling capacitors, C3 sets the high frequency compensation, R10 provides ZERO ADJUSTMENT and R8 sets the FULL SCALE level of 10.000V, with the upper eight bits ON and the lower four bits OFF. Data requiring digital to analog conversion is done simply by OUTPUTTING the data to its corresponding port address where U3 makes the conversion.

A/D CIRCUITRY

Analog to digital conversion of the front panel potentiometers (pots) requires that a software generated successive approximation routine be used. Since the DMUX and the MUX (multiplexer) run synchronously, data can be written to the DAC with all DMUX channels off, while addressing the multiplexer at the same time (except that the MUX addresses "fold over" at 40H, as described earlier in the DIGITAL board section). This is true because any OUTPUT instruction between addresses 40H and 80H will WRITE data to the DAC, but all DMUX 4051s will be off. Since the multiplexer addresses "fold over", a pot with an address in the 0H to 40H range will be put on the MUX buss. The MUX buss comes in from the DMUX board on P516-1 and for the moment disregarding CR2, CR3 and R18-R20, is applied to the non-inverting input of comparator U6A. The DAC is connected to the inverting input of U6A and the U6A output is connected via



DEMULTIPLEXER (DEMUX)

A/D CIRCUITRY (CONT'D)

P517-1 back to the DIGITAL board where its status can be READ by the CPU. An A/D conversion is accomplished by OUTPUTTING approximations to the D/A converter with the address of the pot to be converted plus 40H. For example, if a pot with an address of 10H was to be converted, the first approximation would be to OUTPUT 80H, which is about +5V, to port 50H (10H + 40H). The +5V approximation appears on pin 2 of U6A via the D/A converter and the pot value on pin 3 of U6A via the multiplexer on the FRONT PANEL board. By now, reading the U6A comparator output, the CPU knows whether the voltage on the pot wiper is higher or lower than the +5V approximation. Assuming the pot voltage was higher than +5V, the next approximation would be 7.5V. This approximation routine continues with successively smaller steps - each, half the previous step, until the pot value has been determined.

POTENTIOMETER EDITING

Pot editing is accomplished by detecting pot movement. When a pot is moved, its output replaces the stored program data from memory. In order to detect pot movement, all pot positions must be known at all times. When the unit is turned on it runs a power-up software routine that converts all the analog pot voltages to digital data and records this data in a position table called POTPOS. This POTPOS table is constantly updated in order to maintain current pot position information. The software for the main system loop software contains a routine that systematically outputs the POTPOS table data to the DAC while addressing the multiplexer, to apply the corresponding pot value to the MUX buss. The comparison is done by comparator U6A with hysteresis provided by Q1, U6B, CR2, CR3 and R17-R21. Since, in the case of a pot that has not been moved, both voltages on the inputs of U6A will be nearly equal, some threshold hysteresis is required. By WRITING a zero to the U2 latch Q4, output Q2 will be turned on pulling R17 to +15V. CR2 will be forward biased and will therefore clamp the junction of R17 and R18 to about +0.6V above the MUX buss potential. This will yield a constant drop across R18 of about 0.6V over the normal range of 0V to +10V of the MUX buss. R18 and R19 form a simple divider with the voltage appearing on the U6A input at about 50mV higher than the MUX buss input. This forms the positive hysteresis threshold to detect pot movement while in a similar manner U6B, CR3 and R20 generate the negative limit. If a pot is found to be outside these limits when compared to its latest position, information from the POTPOS table is determined to have been moved and placed the MEMORYMOOG into EDIT.

LEVEL TRANSLATION

Numerous switching functions of the analog synthesizer must be controlled and their data is latched by hex latches U51, U52 and U54-U61. Since the analog data of these switch controls have various levels, their on/off control lines switch from +7.5V to -7.5V, 0V to +15V or as TTL levels. Buffer U50 and transistors Q2-Q7 translate six bits of the buffered data buss to the +7.5V to -7.5V level and the 0V to +15V level. Buffer U53 and Q8-Q12 translate the CLOCK LINE to the +7.5V to -7.5V level.

READING RECOMMENDATIONS

The following books are recommended for additional information on microprocessors like the Z80. These are general references not related to MEMORYMOOG but contain important system concepts.

TRS-80 MICROCOMPUTER TECHNICAL REFERENCE HANDBOOK, Catalog 26-2103, 1978.

PROGRAMMING THE Z80 by Rodney Zaks, 1980 2nd Edition from SYBEX CZ80, Printing 10587654321 ISBNO-89588-047-4.

FRONT PANEL CONTROL BOARDS #6 & 7

Left and right side control board (L.S.C. & R.S.C.) switch cicuitry is almost identical to the keyboard decoder column/row matrix discussed earlier. A 74LS377 latch is on the left side of the L.S.C. board and a 4503 buffer on the left side of the R.S.C. board, connected through connector S75. Thus each board shares common rows. The only thing different compared to the keyboard matrix, are the diodes for each contact - since there is no need to detect multiple switch closures. The FRONT PANEL matrix has two-key rollover, whereby pressing more than two keys ends up shorting bus lines together which decode as an erroneous switch action that was not actually taken. It outputs all "zeros" on the latch and READS all "ones" on the buffer with no switches closed. If it finds anything other than "ones", it scans the latch outputs for the particular row, READS it to the buffer and then proceeds. It READS two bytes of information, first READING the left side, then the right side.

DISPLAYS

Front panel LEDs are also matrixed in a column and row structure. The row data is latched by U1 on the L.S.C. board which drives U2 and U3, also on the L.S.C., which are Darlington driver arrays that provide the necessary current gain. All discrete LEDs on both control boards, along with the eight character drivers for the alphanumeric display,are driven from the U2 and U3 row driver. Column data for the L.S.C. board discrete LEDs is latched by U8 with Q15-Q18 providing the necessary current gain. Column data for the fourteen segments of the alphanumeric display is latched by U4 and U5 with Q1-Q14 providing current gain. The discrete LEDs on the R.S.C. board column data is latched by U2, on the R.S.C., with Q1-Q4 providing current gain. All the above described latches are memory mapped (meaning they are WRITTEN to as if they were memory) by address decoders on the DIGITAL board described in the DIGITAL board section.

The LEDs (including the alphanumeric display) are multiplexed at a one eighth duty cycle with a 100Hz loop rate. This timing is determined by interrupts generated by the CTC on the DIGITAL board as described earlier. Only one row will be on (an output from U2 or U3 low) at any time, while from a table in memory, the corresponding column data (which has been stored there previously) is obtained and WRITTEN to the column latches U8, U4 and U5 on the L.S.C. and U2 on the R.S.C.

The two digit program display consists of a simple 7447 seven segment decoder, 74LS378 latch and two MPSU55 drive transistors. The software routine is similar to the LEDs except that there are only two drives, with the tens and the units digits alternating. A small additional board has been added to early MEMORYMOOG versions to the L.S.C. control board utilizing a 74LS273 in the U1 position which deselects the eight character display and LEDs in the event of a power-down situation. This avoids possible LED damage due to the application of a constant voltage to the LEDs which are normally multiplexed. The 74LS273 has a COMMON CLEAR input which deselects the LEDs if a low voltage condition exists.

All pots are connected between the analog ground and the plus 10 volts which is driven from the 10 volt reference source generated on the DMUX BOARD. The drive to all the pots is in parallel and addressed from the same latched and buffered lines as developed on the DIGITAL board.

6-VOLT DISPLAY REGULATORS
There is a series of 6 volt regulators on the lower right corner of L.S.C. schematic which supplies all the lights. The 5 volt supply is not used because of the diode drops from the Darlington 2704s which have a saturation voltage of about one volt, the 2N3906 PNP transistors and the two volt drop across each LED would provide little voltage across the current control resistors R74, R75 and R76. Therefore, the 6 volt regulators are powered by the RAW 5 volt supply (provides approximately 12 volts) which averages an 800 milliamp draw. The regulated 6 volts is divided up in a seemingly haphazard fashion but this in fact balances the current throughout the FRONT PANEL.

VOICE CARDS BOARD #1 A THROUGH F

THE OSCILLATORS
Starting at the upper left hand corner of the schematic is OSCILLATOR ONE consisting of a 3340 VCO which outputs TRIANGLE, SAWTOOTH and variable width rectangular PULSE waveforms. Refer also to the accompanying VOICE CARD block diagram. Since loading of the TRIANGLE and SAWTOOTH outputs can affect the oscillator frequency slightly, high value base resistors are used. Each one of the outputs feed a 4016 switch and a 3360 VCA. All the waveforms are summable such that SAWTOOTH, TRIANGLE and rectangular PULSE waveforms are available at the same time.

The variable width rectangular PULSE waveform is established by the control signals coming from the COMMON ANALOG board where the pulse width for all voices is set.

There is a provision for PULSE WIDTH MODULATION and also VOICE MODULATION on each VOICE CARD with OSCILLATOR THREE used as the modulation oscillator. All oscillator signals are summed into a 3360 VCA which is controlled by the AMOUNT CONTROL programmed from a DMUX board DAC amount. Following the 3360s, the three outputs are summed into a TL072 U12A. At high volume settings, the signal is clipped in the TL072 for a desirable sounding "distortion effect". The output from the summer goes into Q3, a 2N3904, which is bussed to the AUTOTUNE circuit. Since six VOICE CARDS are bussed together, there is a need for a way to select a particular VOICE CARD and OSCILLATOR. To accomplish this, the collector of Q3 is tied to the FILTER CONTOUR for each VOICE CARD, thereby providing the VOICE CARD selection. Then by turning on the AMOUNT CONTROL for a particular OSCILLATOR and obtaining an independent contour from the CONTOUR/GLIDE board, a specific OSCILLATOR on a particular VOICE CARD can be selected.

The selection process applies a voltage on R131 which allows Q3 to turn on and using the rectangular PULSE waveform from the OSCILLATORS, a pulse is obtained. It is coupled to CR1 and sent out the AUTOTUNE buss to the DIGITAL board. The U12A sums the OSCILLATORS with a NOISE buss from the COMMON ANALOG board. One NOISE source generates the NOISE for all VOICE CARDS and is routed into the filter.

THE VCF
The VCF filter is a 24dB/octave patented Moog filter and it uses an IT122 monolithic matched transistor pair at the top and bottom of the filter ladder to cut down on voltage offsets and improve the current control signal rejection.

All the outputs of the OSCILLATORS and the NOISE source are coupled to the base of Q11(2) via C26. Q11 (1 and 2) convert the input signal to a differential signal current in the ladder. The collector, capacitor C31, and the next set of emitters Q9 and 10 form a 1 pole current controlled low pass filter. The cutoff frequency of the filter is directly proportional to the standing current in each leg of the ladder. The four stages in the ladder add up to a four pole low pass filter.

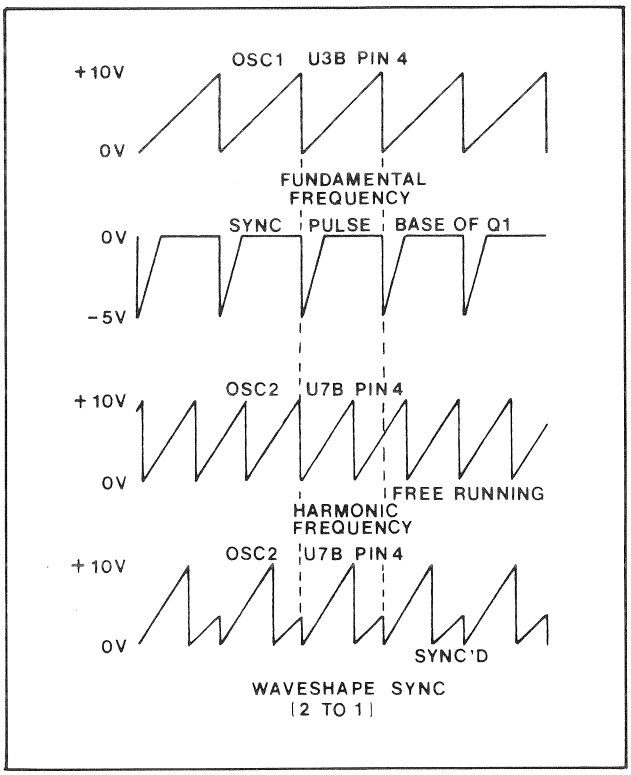
The filter ladder is controlled by current from an exponential current source U14 that also uses an IT122. The control current to the filter comes from many sources, such as: the FILTER CONTOUR of the CONTOUR/GLIDE board, the KEYBOARD VOLTAGE, COMMON ANALOG control signals which sum the FILTER CUTOFF, FREQUENCY MODULATION and OSCILLATOR 3 MODULATION.

VOICE CARDS BOARD #1 A THROUGH F (CONT'D)

All are summed together, scaled with R167 and offset adjusted with the RANGE adjust R164 and applied to the exponentiator that drives the VCF. The filter signal is obtained differentially by a 353 BIFET OP AMP U20A and U20B. The 353 has a gain factor of approximately 4, which brings the signal up to about 100 millivolts, when the filter is all the way up. That signal has enough drive to obtain distortion in U22, the 3080 OTA, for a "fat" overdrive sound. The distortion is severe enough to alter a triangle waveform into a sinewave at the output with the LEVEL controls up and the VCF "open" all the way. The offset is cancelled with VCA TRIM R140 which takes out any "thumping sounds".

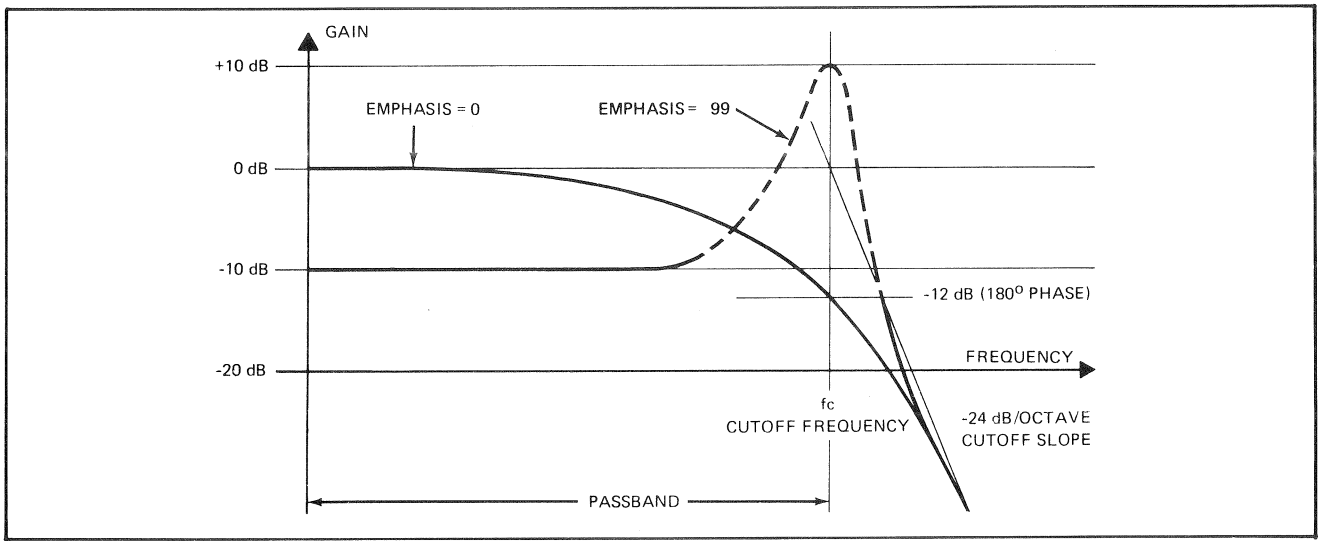
Next, the signal is applied to a 3080 OTA, the EMPHASIS amplifier U21, where it is attenuated with R147, R148 and R149. It is attenuated because distortion is wanted in the final output VCA but NOT in the EMPHASIS circuit as it creates undesirable sound effects. The signal, in turn, drives the inverting input of Q11 to generate the EMPHASIS. The total phase shift of the filter is equal to 180 degrees at the cutoff frequency of the filter and this signal is injected into the minus input of the filter, resulting in positive feedback. This establishes a resonent peak in the filter response at the cutoff frequency. The height of the peak depends on the setting of the EMPHASIS control. At full emphasis the filter will oscillate producing a sine wave. EMPHASIS trim R153 sets the oscillation threshold and EMPHASIS BALANCE trim R151 cancels any voltage offset of U121.

The EMPHASIS control line comes from the COMMON ANALOG board, where all lines are bussed together such that one line controls all VOICE CARDS. The audio output from the 3080, U22, is fed back to the COMMON ANALOG board where it is summed with the other five VOICE CARDS.

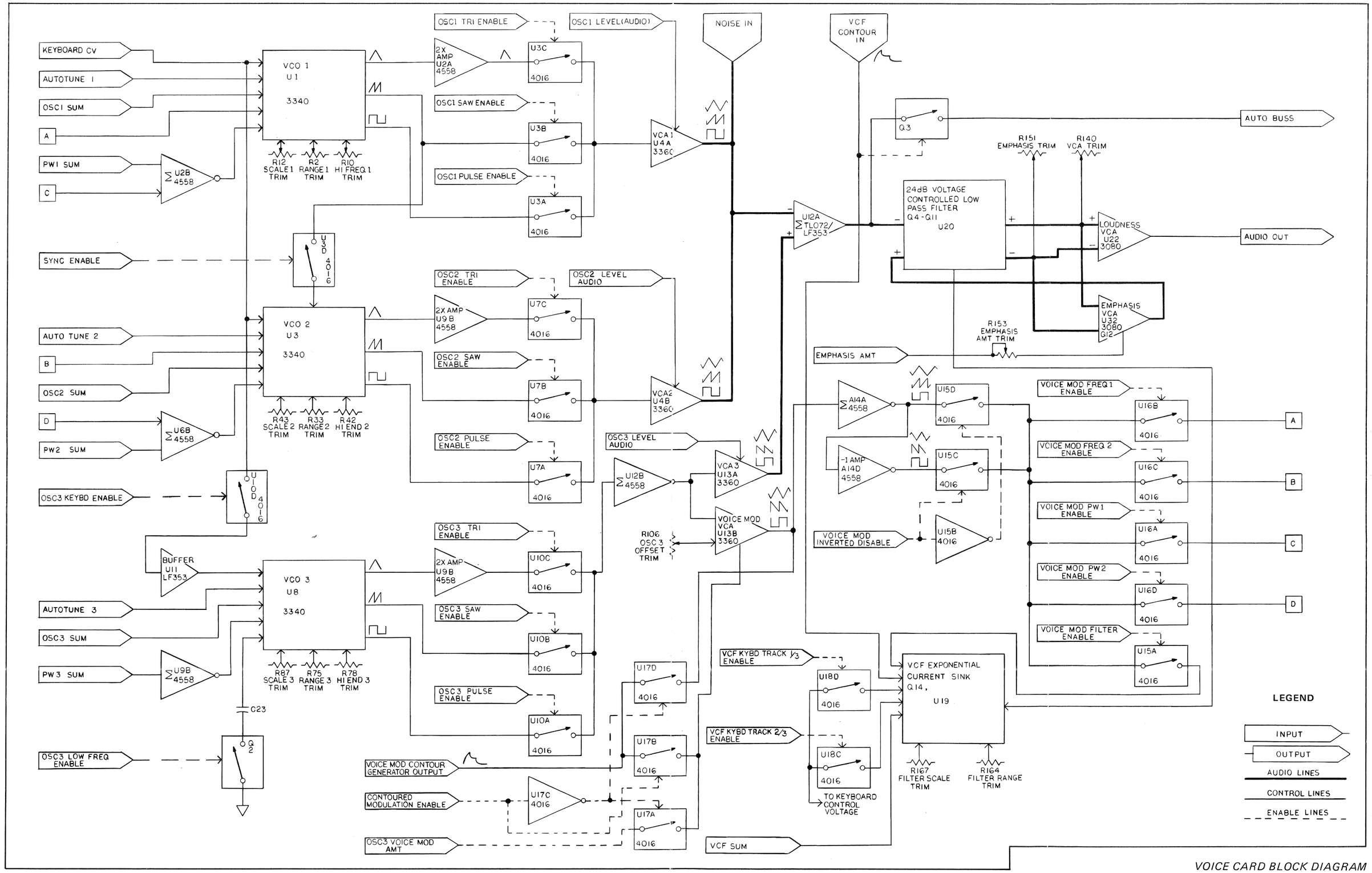


OSCILLATOR SYNC

OSCILLATOR SYNCHRONIZATION (SYNC)
OSCILLATOR TWO is identical to OSCILLATOR ONE except for the SYNC capability. The SAWTOOTH output from OSCILLATOR 1 is applied through U3D, a 4016 switch to OSCILLATOR 2. When U3D is ON, it is differentiated from a narrow pulse which turns Q1 on and effectively shorts out the TRIANGLE output for about 100 microseconds. This discharges capacitor C12, the timing capacitor for OSCILLATOR 2, resulting in a complex SYNC waveform where OSCILLATOR 1 is free running and OSCILLATOR 2 is synchronized to OSCILLATOR 1. The fundamental frequency of OSCILLATOR 2 is now "locked" to OSCILLATOR 1.



VCF FREQUENCY RESPONSE CURVES



VOICE CARD BLOCK DIAGRAM

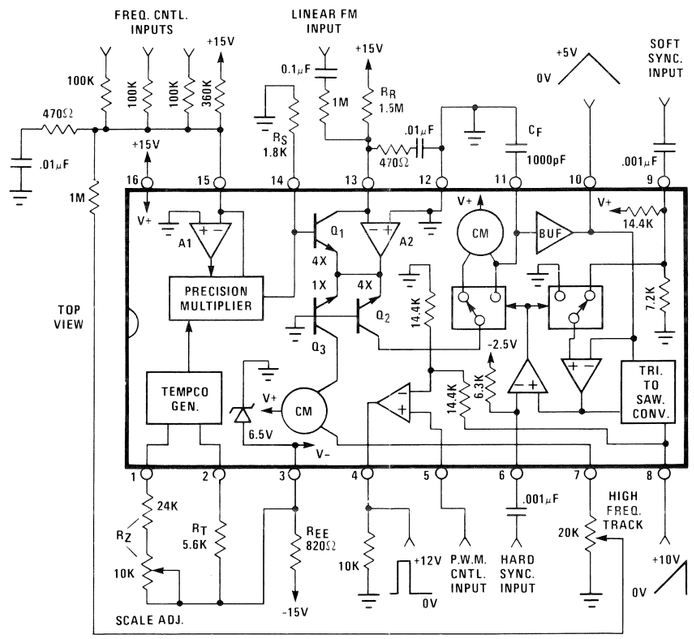
CEM 3340
VOLTAGE CONTROLLED OSCILLATOR

The CEM 3340 is a completely self-contained, precision voltage controlled oscillator, featuring both exponential and linear control scales and up to four buffered output waveforms: triangle, sawtooth, square and pulse with voltage controllable pulse width. Full temperature compensation makes these VCOs extremely stable and eliminates the need for a temperature compensation resistor. The highly accurate exponential and linear control inputs are virtual ground summing nodes, allowing multiple control voltages to be mixed within the device itself.

Also included is provision for hard and soft synchronization of the frequency and an output for easy adjustment of high frequency tracking. Special care in the design ensures oscillation start-up under any power on sequence and supply conditions.

Although a low voltage process has been used to reduce die size, cost and leakage currents, an on-chip 6.5 volt zener diode allows the device to operate off +/- 15 volt supplies as well as +15, +5 volt supplies.

ABSOLUTE MAXIMUM RATINGS
Voltage between VCC and VEE pins
+24V, -0.5V
Voltage between VCC and Ground Pins
+18V,-0.5V
Voltage between Frequency Control Pin or Reference Current Pin and Ground Pin
+/-6.0V
Voltage between Multiplier Output Pin and Ground Pin
+6.0V, -1V
Current through Any Pin
+/-40mA
Storage Temperature Range
-55 degrees C to +150 degrees C
Operating Temperature Range
-25 degrees C to +75 degrees C

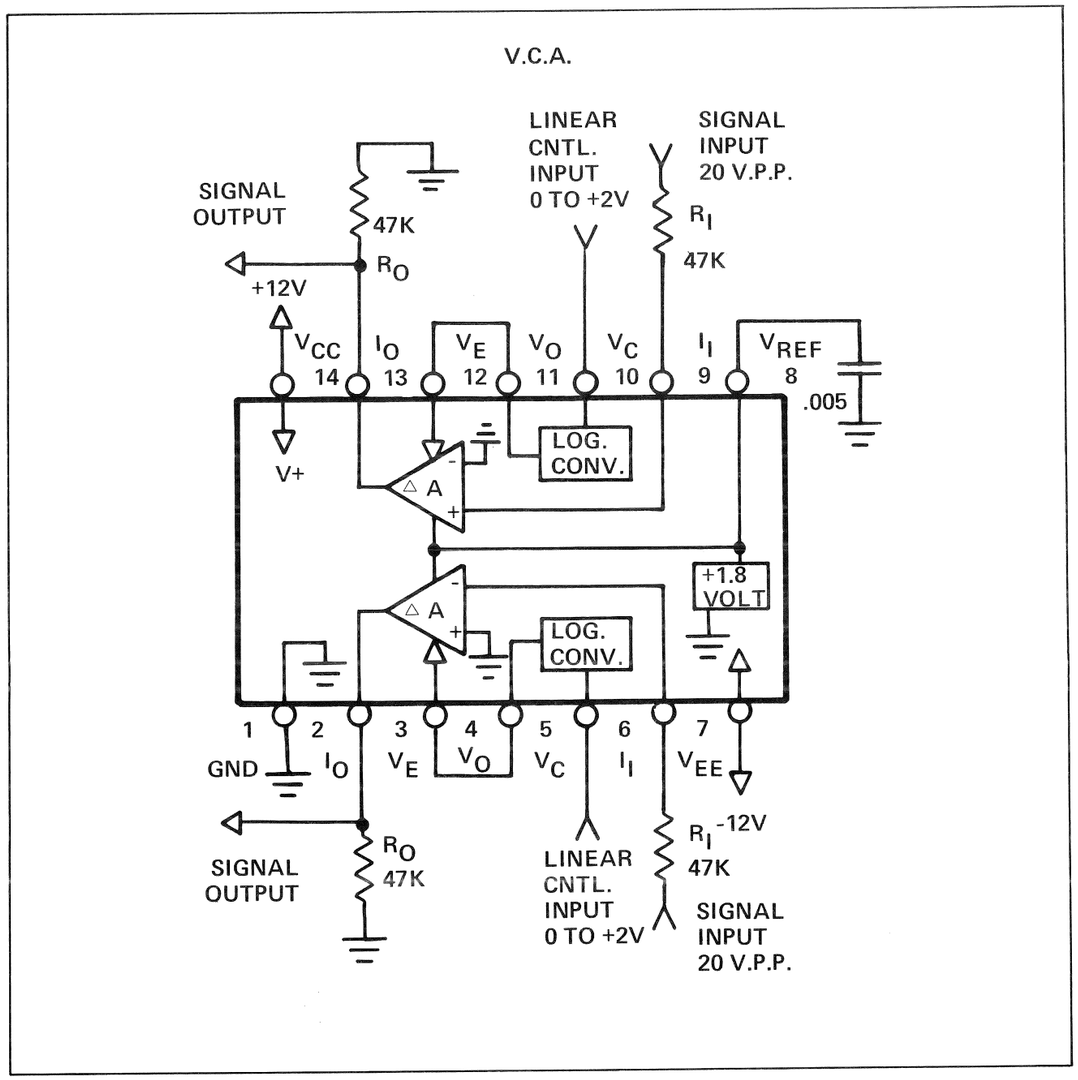


CEM 3340 CIRCUIT BLOCK AND CONNECTION DIAGRAM

INFORMATION SUPPLIED COURTESY OF
CURTIS ELECTROMUSIC SPECIALTIES

CEM 3360
DUAL VOLTAGE CONTROLLED AMPLIFIER

The CEM 3360 is a dual general purpose voltage controlled transconductor intended for such application as voltage controlled amplifiers, filters & waveform generators. Each transconductor independently provides both linear and exponential control scaling over greater than a 100dB range. Complete with virtual ground summing inputs, wide voltage compliance current outputs and control inputs referenced to ground, the CEM 3360 requires few external components and it is extremely easy to use. Because of its inherent ultra-low control feedthrough, no trimming is required. Added to these features are exceptionally low noise, wide bandwidth and operation down to +/- 3 volts, making the CEM 3360 a real cost saver in most applications requiring variable transconductance amplifiers.



CEM 3360 BLOCK DIAGRAM AND TYPICAL CONNECTION

INFORMATION SUPPLIED COURTESY OF
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VOICE MODULATION

OSCILLATOR 3 has a few differences from OSCILLATOR 1 in that the KEYBOARD VOLTAGE can be disconnected through the switch U10 and instead used as a modulation source. The modulation is only about one hertz, however, driving the 3340 VCOs with a control voltage input of such a low level causes the TRIANGLE waveform to be unsymetrical. Therefore, Q2 is used as a low frequency switch. With the low frequency switch on, Q2 is turned on and places a .033uf capacitor, C23, in parallel with the .001uf capacitor C22. This drops the frequency approximately 32 times or about five octaves. Since a DC output is needed from OSCILLATOR 3 for modulation, the three waveforms are summed by a TL072, U12B, and applied to two 3360 VCAs, U13A and U13B. U13A is used for establishing the level which controls the audio into the summer and U13B is the VCA for VOICE MODULATION when OSCILLATOR 3 is used as a modulation source. To prevent bleedthrough through the transmission gates, the 3360, final VCA drive, is shut off by the software. In that way, turning off the WAVEFORM switches allows no bleedthrough because the 3360 is completely off. Again, U13B is the VCA for the VOICE MODULATION and its output is fed into inverter A14A and another inverter, A14B, resulting in an inverted and a non-inverted output. These two waveforms are made available with another modulation source, the FILTER CONTOUR VCA, from the CONTOUR/GLIDE board, providing either straight or inverted contours. Therefore, all standard and reverse waveforms are available which can be coupled through the various electronic switches to inputs controlling OSCILLATOR FREQUENCY, PULSE WIDTH or FILTER CONTOUR.

Since everything is located on the VOICE CARD or at least associated with individual VOICE CARDS, this phenomenon is called VOICE MODULATION, which is "independent" for every VOICE CARD. It means that a selected TRIANGLE WAVEFORM can be turned on for OSCILLATOR 3, on a particular VOICE CARD and can have completely different, all independent, PULSE WIDTHS and FREQUENCIES. Similarly, the FILTER CONTOUR can be activated on a voice by voice basis capable of creating a sweeping effect of the OSCILLATORS. It is also possible to take the FILTER CONTOUR, turn the VCA all the way up and use that to control the VCA for OSCILLATOR 3. Then using the FILTER CONTOUR to adjust a slow ATTACK time would produce delayed modulation on a VOICE CARD by VOICE CARD basis.

-5 VOLT REGULATOR

The 3340 VCOs need to operate at +15V and at less than -7.5V, because they use a low voltage process. U23, a three terminal 79L05 -5Volt regulator, at the central right portion of the schematic, powers these chips for the negative rail. Operation then is at +15V and -5V.

CONTOUR/GLIDE BOARD

POLYPHONIC GLIDE

The DMUX board generates six independent pitches for the VOICE CARDS. To add polyphonic glide to each voice, in the upper left-hand corner of the schematic is an input line labeled POLYGLIDE. It is basically a linear glide circuit which uses a 3360 VCA. The signal for each one of the VOICE CARDS comes in on lines S32-2 through 9 and is divided down with .01% matched resistors to obtain a precise 50% reduction. These lines are applied to a 4558 which is connected as a comparator, the output of which drives the 3360 VCA. The 3360 is a current-in current-out transconductance multiplier with the current set by R5. The current out is equal to the current in times the control voltage on pin 3. The maximum gain is obtained when pin 3 is at +2 volts. For example, starting from zero volts at S32-9, then applying +10 volts, 5 volts would appear at the input of the 4558 which would drive the output on pin 1 high providing a positive drive current to the 3360. This would, in turn, generate another output current on pin 2 which is proportional to the control voltage on pin 3. C1 is charged with the current source yielding a linear RAMP voltage which Q1 will follow until the voltage on the source of Q1 equals 5 volts. At 5 volts, the 4558 output will go to zero, stop the charging current and hold it there, controlling the GLIDE time. The higher the control voltage on the 3360, the higher the output current, the faster 5 volts is reached. Therefore, the larger the control voltage on pin 3 of the 3360, the faster the GLIDE time.

The POLYGLIDE amount is bussed to all the GLIDE circuits and each pair of RANGE trimmer outputs are set for the maximum GLIDE time. The control of the dual 3360s is made by applying the same voltage to both pins 3 and 12 of each device which are the exponential inputs (the 3360 has its own internal exponentiator). Thus, POLYPHONIC GLIDE means that each individual VOICE will glide from the last note played on the keyboard.

MONOPHONIC GLIDE & EXTERNAL SYNTH (BOARD #9)

There is also a separate MONOPHONIC GLIDE output. Whereas six VOICE CARDS will not precisely track no matter how accurately they are adjusted, in POLYPHONIC GLIDE it doesn't matter because they move independently as played. But playing all six VOICE CARDS with MONOPHONIC GLIDE means they must all glide together. In the POLYPHONIC mode all the 3360s are turned ON and the MONOPHONIC GLIDE is turned OFF by setting it to the minimum. In the MONOPHONIC mode, the six 3360s are turned OFF and the MONOPHONIC GLIDE is turned ON. The GLIDE output is coupled through the TRANSPOSE circuit and goes back into the MASTER SUMMER on the COMMON ANALOG board so it will affect all the VOICE CARDS. It has a GLIDE RANGE trimmer but the second half of the 3360 is not

connected. Also, this MONOPHONIC OUTPUT drives the small #9 board on the MEMORYMOOG back panel where two inverters, U1A and U1B, provide the EXTERNAL SYNTHESIZER CONTROL VOLTAGE (C/V) OUTPUT. SCALE and RANGE trims are accessible through the rear panel for adjustment of the MEMORYMOOG. The MONOPHONIC EXTERNAL SYNTHESIZER C/V OUTPUT tracks the low, high or last note depressed on the keyboard, depending on what is programmed. The control voltage output from the MONOPHONIC GLIDE circuit is summed in with the TRANSPOSE circuit.

TRANSPOSE

The TRANSPOSE circuit operates in a MONOPHONIC, POLYPHONIC and TRANSPOSER HOLD mode. In the HOLD MODE the MEMORYMOOG remembers what chordal notes were played last and will play those same three notes transposed based on the next note played. At the lower left hand corner of the schematic is the circuitry which buffers the TRANSPOSE signal consisting of U7B and associated OFFSET and SCALING trims R53 and R286.

ADSR CONTOUR CIRCUITRY

The contour lines enter from the DMUX board at the upper left hand portion of the schematic where the ATTACK, DECAY and RELEASE are buffered and applied to the 3310 Contour Generator. The usual ADSR contour includes an ATTACK, two holds and a RELEASE, but if a second note is played the contour would start back up from whatever DECAY or RELEASE setting it subsided to and reach its ATTACK setting more rapidly than is normal. This is not a desirable condition for the rearticulation of chords, therefore turning ON the RETURN TO ZERO front panel switch causes the Contour Generator to short to zero, thus providing a rearticulation of the entire ATTACK phase. In the UNCONDITIONAL CONTOUR mode, once a trigger is established, the contour will continue and the entire ATTACK phase automatically will proceed into the RELEASE phase (even if a note is not held down). In the KEYBOARD FOLLOW mode, the control voltage from the individual VOICE CARDS is used to reduce the ATTACK, DECAY and RELEASE times as notes are played up the keyboard. It is like a piano in which a note played on the bottom lasts a long time, while a note played at the top lasts only a short time. The keyboard follows or simulates that acoustic property with control voltages and as the keyboard is played with higher pitches, with the KEYBOARD FOLLOW switch ON, the DECAY, ATTACK and RELEASE get progressively shorter. There is also a RELEASE SWITCH which when OFF, the contour drops to zero immediately following the ATTACK, DECAY and SUSTAIN phases. When it is ON, the contour fades away at the rate set by the RELEASE potentiometer.

LOUDNESS ENVELOPE GENERATOR CIRCUITRY

All the contours are generated by a series of six 3310 Envelope Generators. There are four control voltage inputs for the ENVELOPE GENERATORS: ATTACK, DECAY, SUSTAIN and RELEASE and attack out is the output from the 3310. The 3310 has its own current mirrors, comparator and exponential current sources. Therefore, by changing the voltage on pin 16 of U17, it changes the charge time during the ATTACK phase, thereby creating a voltage controlled Envelope Generator. Considering the 3310 as a straightforward Envelope Generator, every time a key is depressed on the MEMORYMOOG, the keyboard logic decodes which note is on and which VOICE CARD it is on. Thus, pressing a key would result in one of trigger inputs A-F actuating. If TRIGGER A is on, for example, the trigger is coupled through the 74LS32 U16A to the input and is differentiated by C24 and applied to the 3310 trigger input. This starts the ATTACK phase.

Without a trigger, the Envelope Generator will not start but once the gate is on, U17 operates as a standard Envelope Generator. When the ATTACK phase reaches the maximum ATTACK level, the comparator inside goes into a DECAY phase which proceeds to the SUSTAIN level. The DECAY rate is set by the control voltage on pin 13 and the SUSTAIN level is set by the control voltage on pin 12. The exponential input is just like a typical oscillator input operating at approximately 18 millivolts per octave/time. The longest attack time is when U13B is at zero. The more negative this input becomes, the shorter the ATTACK. That time is cut in half for every 18 millivolt decrease.

The SUSTAIN holds for as long as the gate is on. When the gate goes off, the VCA RELEASE phase starts. If the RELEASE switch is ON it will decay at the rate set by the RELEASE control voltage from the DMUX output. If the RELEASE switch is turned OFF, the computer tells the DMUX output to go to maximum which yields the fastest decay time. U18A is a 353 acting as a buffer for the sample/hold capacitor C27. The output of the 353 is fedback into the 3310 and this feedback loop creates exponential-type responses. The Envelope Generator is set by resistor R113 for the longest desired ATTACK time and all the Envelope Generators are similarly matched. The VCA output then has specific wires fed to individual VOICE CARDS.

FILTER CONTOURS

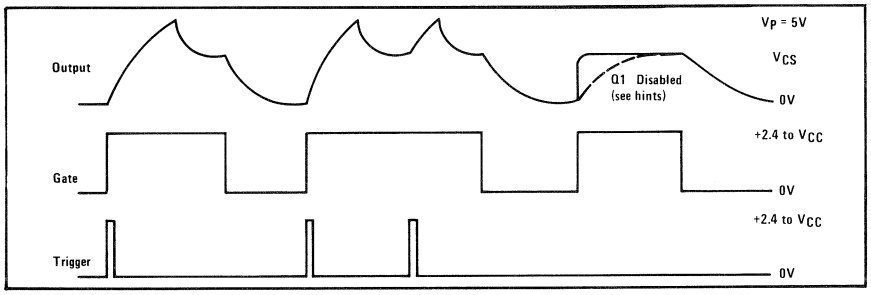
The FILTER Envelope Generator is configured like the LOUDNESS Contour Generator, except that there are two AMOUNT VCAs: one for the FILTER CONTOUR AMOUNT control and the second for VOICE MODULATION. VOICE MODULATION is fed to each individual VOICE CARD and is buffered.

Looking back at the CONTOUR INPUTS, the UNCONDITIONAL ATTACK phase input is fed to a 393 U14A through a 74LS08 U15C. During the ATTACK phase, pin 16 ATTACK OUT will drop slightly negative to about -1 volt. That will turn the output of the 393 on and couple it through the 74LS08 which is ANDED with the UNCONDITIONAL ATTACK.

CEM 3310
VOLTAGE CONTROLLED ENVELOPE GENERATOR

The CEM 3310 is a self-contained, precision ADSR type of envelope generator intended for electronic music and other sound generation applications. Attack, decay and release times are exponentially voltage controllable over a wide range and the sustain level is linearly voltage controllable from 0 to 100% of the peak voltage. A unique design approach allows for a 10,000 times improvement in control voltage rejection over conventional designs. In addition, much care has been given to the accuracy, repeatability and tracking of the parameters from unit to unit without external trimming. The times are to a first order determined only by the external resistor and capacitor and the constant of physics, KT/q. Wide tolerance monolithic resistors are not used to set up the time constants or the control scale. Finally, all four control inputs are isolated from the rest of the circuitry so that the control pins of tracking units may be simply tied together. Although a low voltage process has been used to lower the cost and lower the leakage currents, an internal 6.5 volt Zener diode allows the chip to be powered by +/- 15 volts supplies, as well as +15, -5 volt supplies.

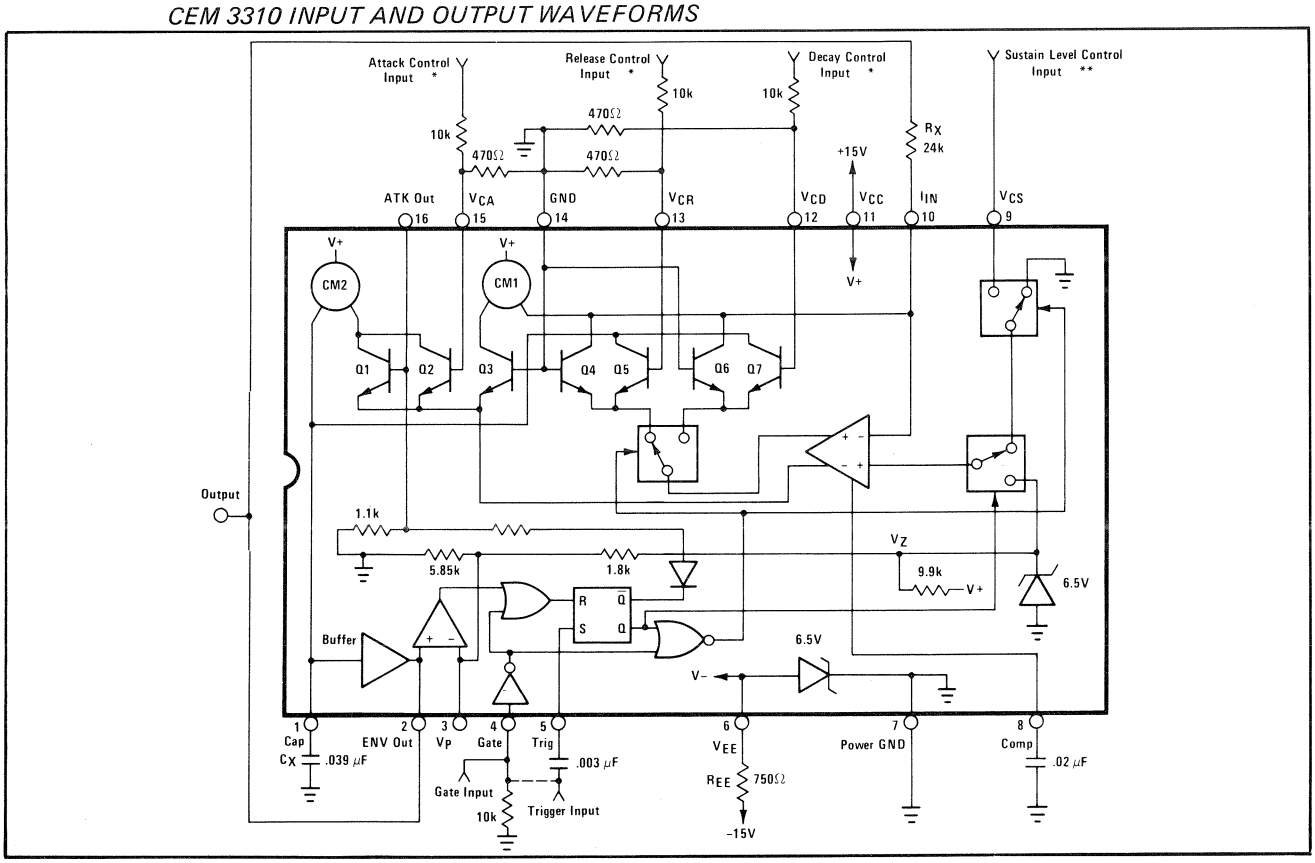
ABSOLUTE MAXIMUM RATINGS
Voltage between VCC and VEE Pins
24V
Voltage between VCC and Ground Pins
+18V
Voltage between VEE and Ground Pins
-6.0V
Current into VEE Pin
+/-50mA
Voltage between Control and Ground Pins
+/-6.0V
Voltage to Gate and Trigger Input Pins
VEE to VCC
Storage Temperature Range
-55 degrees C to +150 degrees C
Operating Temperature Range
-25 degrees C to +75 degrees C



* Zero to -5V Varies the Times from 2mS to 20S

** Zero to +5V Varies the Sustain Level from 0 to 100%

CEM 3310 INPUT AND OUTPUT WAVEFORMS



CEM 3310 CIRCUIT BLOCK AND CONNECTION DIAGRAM

INFORMATION SUPPLIED COURTESY OF
CURTIS ELECTROMUSIC SPECIALTIES

CONTOUR/GLIDE BOARD (CONT'D)

This trigger is basically on and operating and the 74LS08 keeps this 74LS32 OR gate on. In other words, when a key is pressed down, U15 turns on and turns the 74LS32 on which holds the trigger on. As soon as the ATTACK phase ends, it jumps positive again, turns off and eliminates the trigger. If a note is still held down, a trigger will still exist but if the key is just "tapped", the ATTACK will begin and once completed it will go to the RELEASE phase.

The RETURN TO ZERO is accomplished with Q8 and Q9. The trigger input is differentiated by C25 and R116 and applied to the base of these transistors such that every time there is a trigger, it momentarily turns on the transistors and shorts C27 and C31. This means it will momentarily bring the contour down to ground. For the KEYBOARD FOLLOW, a bank of 4016s connects to each one of the CONTOUR GLIDE outputs. They are inverted and applied to the 3310 reference, pin 14, from which all the ATTACK, DECAY and RELEASE times are referenced. Therefore, changing the KEYBOARD VOLTAGE changes the reference voltage which, in turn, changes the apparent ATTACK, DECAY and RELEASE voltages which affects the time rate. Each one of the DMUX outputs is inverted for the ATTACK, DECAY and RELEASE time and is output to the VOICE CARDS on three-wire cables.

COMMON ANALOG BOARD #2

FOOT PEDAL CIRCUITRY
Starting at the upper left-hand corner of the schematic, analog control voltage from the rear panel FOOT PEDAL(s) is applied to U1A and U1B, the 3360 VCAs. FOOT PEDAL control AMOUNT is applied through the linear control inputs of the 3360 (pins 5 and 10 respectively) by a preprogrammed amount from the FRONT PANEL controls. The signal is buffered by a 4558 U2A&B and applied to a series of 4016 ENABLE switches driven from DMUX board latches. Depending on what is selected from the FRONT PANEL switches, the FOOT PEDALS are programmed for PITCH, FILTER CUTOFF or VOLUME for FOOT PEDAL #1 and MODULATION or OSCILLATOR 2 for FOOT PEDAL #2. The FOOT PEDAL information is routed to MASTER OSCILLATOR SUMMERS.

The FOOT PEDALS are wired with normaling jacks such that a FOOT PEDAL in either input automatically routes it to the other. Therefore, one FOOT PEDAL can control all the functions of the instrument. If two FOOT PEDALS are plugged in, the functions are separated.

A ZERO and OFFSET trim eliminate the offsets of the 4558 and 3360 to avoid any pitch shift in the output. When the FOOT PEDALS are not used, a constant voltage is applied to the final VCA to turn it ON, thereby the MEMORYMOOG will always have an output. In addition, the software deactivates the VOLUME ENABLE from ever coming on, eliminating an owner trap. That is, if no FOOT PEDAL is inserted and the FRONT PANEL VOLUME push button is ON, the MEMORYMOOG would normally output a zero control voltage and the instrument would be "dead". However, this function is disabled in the software to make the unit trap free.

LHC CIRCUITRY (BOARD #10)
Below the FOOT PEDAL circuitry is the FRONT PANEL TUNE CONTROL, and the OCTAVE switch which mounts on the LEFT HAND CONTROLLER. These are summed through the 4016 switch U4A such that during AUTOTUNE these functions do not affect the pitch READ to the CPU. During normal operation, U4A is ON but during AUTOTUNE it is OFF to eliminate the TUNE and OCTAVE from affecting the AUTOTUNE frequencies.

The TUNE control is a standard divide down potentiometer and the OCTAVE circuitry is mounted on board #10. The OCTAVE has a dual 393 comparator hooked up as a SET/RESET flip-flop. When "-1" is depressed, it sends the output of U1A high and latches the output of U1B low, turning the latch ON. When the "-1" output goes high, it turns Q1 off and sends a voltage from U32 into the MASTER OSCILLATOR SUMMER to drop the oscillator summers one octave.

The PITCH WHEEL is also summed in through dead band diodes CR1 and CR2 and applied to VCA U5A. A programmed PITCH BEND AMOUNT of from one semitone to an octave is present from the program but can be overridden by the LEFT HAND CONTROLLER or FOOT PEDAL #1.

Next, there is a monophonic TRANSPOSE input from the DMUX board that is originally generated on the CONTOUR/GLIDE board and is summed in turn, driving all the OSCILLATORS through the individual MASTER SUMMERS.

THE MODULATION OSCILLATOR
The 3340 U22 is the MODULATION OSCILLATOR which has a rate control input which is taken from the CPU. It also has a modulation RESET input for ARPEGGIATOR functions which is software controlled such that a note played on the keyboard when in the ARPEGGIATION mode, develops a short spike. This spike goes to Q8 which momentarily shorts out the OSCILLATORS. It's like a "SYNC" input whereby the OSCILLATORS can be "RESYNC'd" while playing to keep everything "in time". The outputs are connected conventionally with the TRIANGLE, SAWTOOTH, REVERSE SAWTOOTH (inverted by U23B) and PULSE outputs connected through a series of electronic switches to VCA U11B which controls the MODULATION AMOUNT.

The MODULATION AMOUNT is controlled by FOOT PEDAL #2 through switch U3D and either the LEFT HAND CONTROLLER MODULATION WHEEL or from the programmed FRONT PANEL MODULATION AMOUNT as provided from the DMUX board. Thus, for any particular program, the preset MODULATION AMOUNT may be overridden by the LEFT HAND CONTROLLER

or FOOT PEDAL #2. All these modulation signals are summed together, routed to VCA U11B, buffered by the 741, U12, applied to another series of 4016 switches and ultimately applied to the MASTER SUMMERS for OSCILLATOR, PULSE WIDTH and FILTER CUTOFF.

S & H AND NOISE CIRCUITRY

Included in the MODULATION OSCILLATOR output to U11B is the SAMPLE AND HOLD and NOISE outputs. In the lower right hand corner, the output from the MODULATION OSCILLATOR PULSE is used as a sampling pulse for the SAMPLE AND HOLD. Also, located there is U25, a 5837 pseudo-random digital noise generator followed by a pink noise filter and gain recovery amp U26A. The pink noise output is fed to a 3360 VCA volume control which is buffered by a 4558 U26B and routed out the NOISE bus to all VOICE CARDS. The pink noise is also low pass filtered by R215 and C25 and routed to a 353 buffer U27B, into the SAMPLE AND HOLD circuit consisting of E112 FET Q7 and buffer U27A. The NOISE is sampled by a positive edge from the PULSE waveform and the output from U27A is connected to a 4016 switch U14B which then serves as another MODULATION source.

The control signals discussed above are now applied to the various MASTER SUMMERS for ultimate distribution to the six VOICE CARDS. It should be noted that FRONT PANEL CONTROL voltages are first digitized and then reconstructed to analog voltages again after processing by the CPU. This allows the use of the analog control values by the VOICE CARDS and storage of the digital value of these analog voltages by the CPU for reference and display purposes.

MASTER SUMMING CIRCUITS

In the top center of the schematic are U15, U16 and U17, 4558 inverters that sum inputs for OSCILLATORS 1, 2 and 3 respectively. Each one is followed by another inverter stage of the same IC. Each has OFFSET, OCTAVE and SUM adjustment trimmers. All OSCILLATORS sum PITCH, OCTAVE, MONOPHONIC MODULATION AND TRANSPOSE and then uniquely sum specialized functions like OSCILLATOR 2 FREQUENCY, OSCILLATOR 3 FREQUENCY, etc. The LOW FREQUENCY/KEYBOARD CONTROL, for example, is a special control input for OSCILLATOR 3 which increases its range from +/- one octave to +/-2.5 octaves whenever OSCILLATOR 3 is used in the VOICE MODULATION mode.

Similarly, to the right of the MASTER OSCILLATOR SUMMERS are the MASTER PULSE WIDTH SUMMERS which sum pulse width contol voltages. Still further to the right is the MASTER FILTER SUMMER which sums the FRONT PANEL FILTER CONTROL, the FILTER MODULATION pitch and cutoff outputs.

MONOPHONIC/POLYPHONIC FUNCTIONS

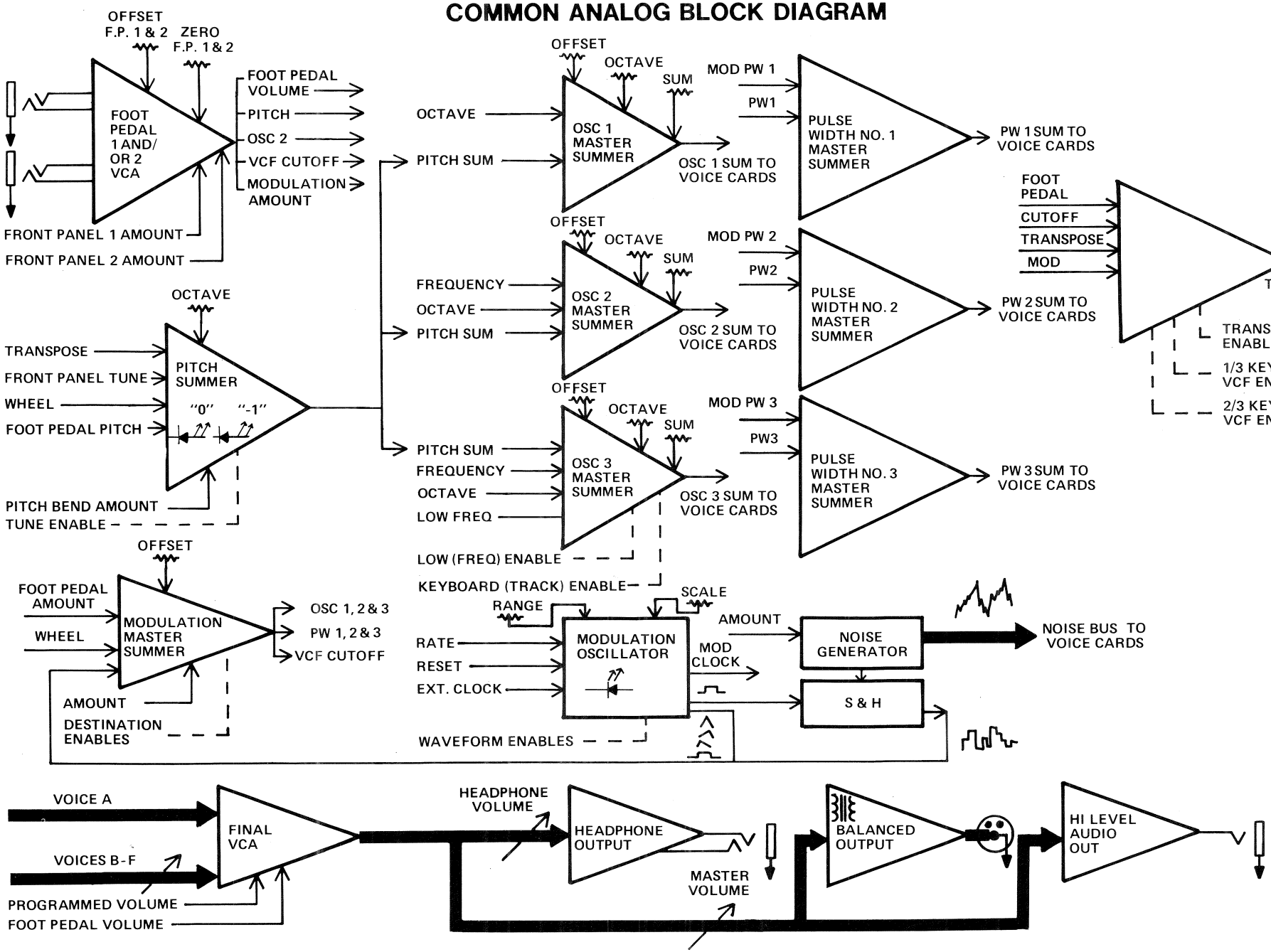
The MEMORYMOOG can be operated as a six voice polyphonic or a monophonic synthesizer which means between one and six VOICE CARDS can be selected to track the keyboard. Furthermore, in the HOLD mode, an entire chord can be transposed when a new single note is played. Thus, there is a need for the keyboard to output six independent drives for the VOICE CARDS for POLYPHONIC operation and a MASTER signal to drive all VOICE CARDS simultaneously for MONOPHONIC operation. In addition, there are certain applications where it is desirable for the FILTER to track a voltage proportional to the monophonic keyboard voltage.

Switches U28C&D provide the monophonic keyboard voltage when in the MONOPHONIC mode and turn ON while the normal VOICE CARD switches are turned OFF. This provides a common keyboard tracking signal to all VOICE CARDS. Zener diodes CR10 and CR11 level translate the FILTER ENABLE signal from zero to 15 volts down to +/- 7.5 volts for use by the 4016 switches.

THE AUDIO OUTPUT

At the lower left hand corner, the audio output from each VOICE CARD is summed together. Notice that VOICES B through F have individual trim pots to match the output VOLUME of each VOICE CARD to the A VOICE. The output is summed into a 3360 VCA which has a programmable output signal from the DMUX board such that a preset volume can be established for different programs. Therefore, FILTER CUTOFF variations can be compensated for with PROGRAMMED VOLUME levels. The output of the VCA is routed to U6B, another VCA which is for FOOT PEDAL override. This, in turn, is applied to a 353 buffer U7B, the output of which is routed to the MASTER VOLUME control on the FRONT PANEL. It returns through shielded cable to U7A, a 353 buffer, and next is applied to the unbalanced high level AUDIO OUTPUT. In turn, the audio is connected to T1, an interstage transformer which provides a BALANCED OUTPUT. The signal is also applied to the HEADPHONE VOLUME control through an LM386 and finally to the HEADPHONE output jack. The 386 IC must be powered at less than 15 volts, therefore the 15 volts is dropped to 11 volts through Q2.

COMMON ANALOG BLOCK DIAGRAM

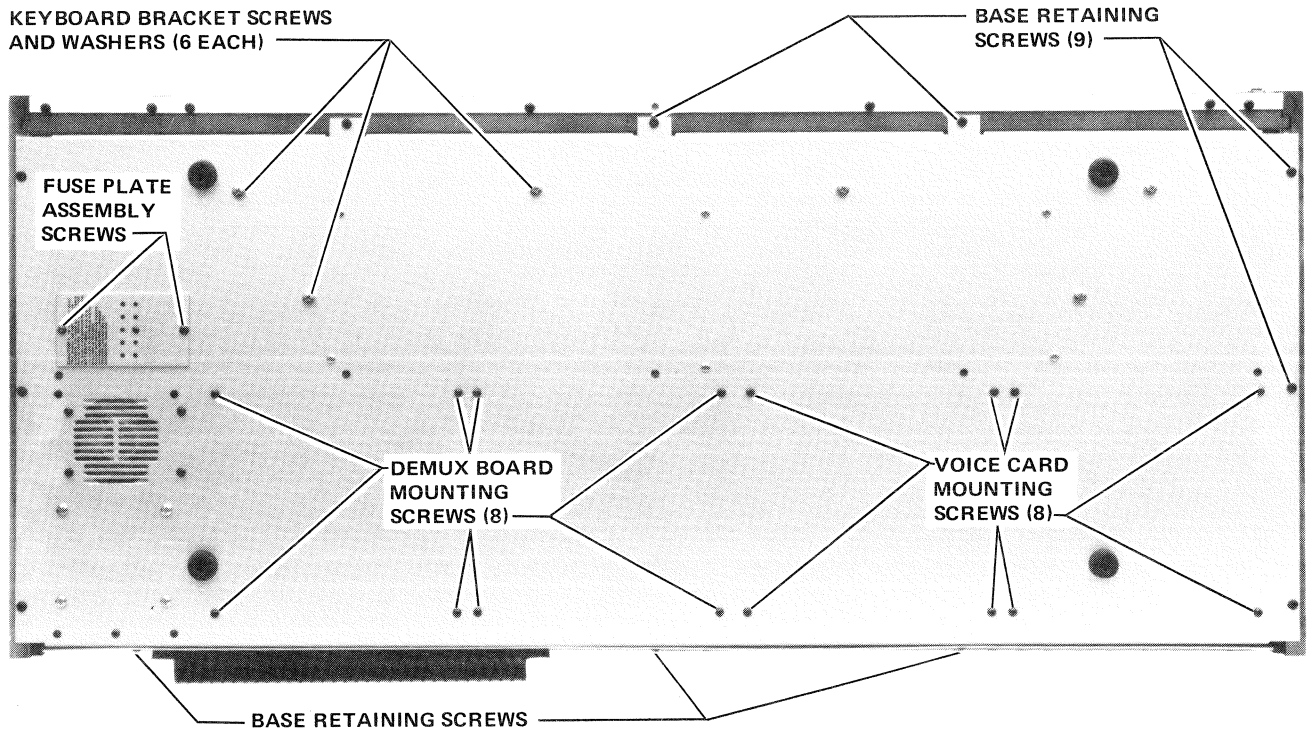


DISASSEMBLY AND REASSEMBLY
(Refer to the Accompanying Photographs and Diagrams)

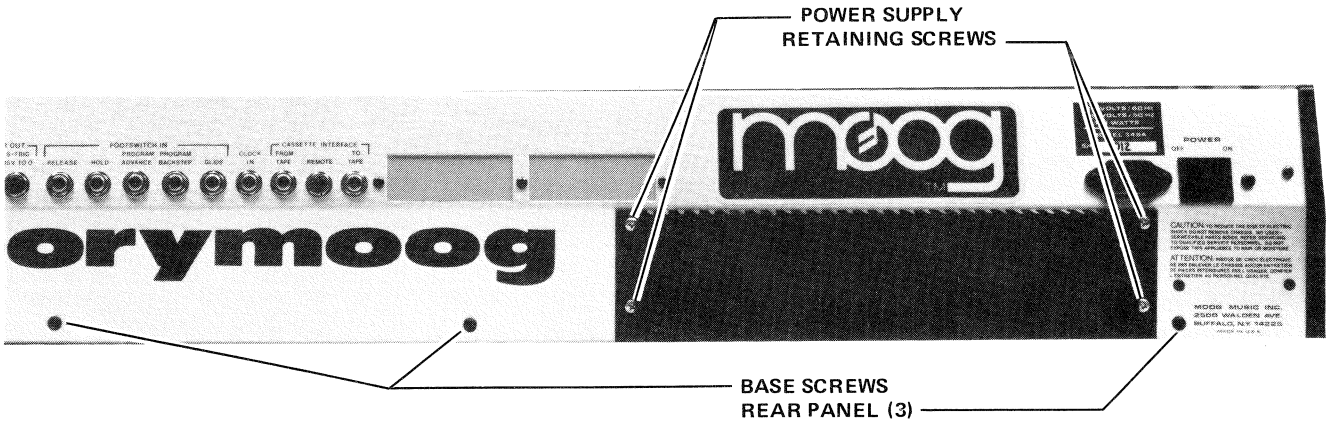
REMOVING THE BASE
With the unit right side up on the workbench and the keyboard facing away, remove the three (3) self-tapping sheet metal screws on the rear panel. Remove the nine (9) self-tapping sheet metal screws, three (3) on either side, three (3) along the front of the base, by letting the edge of the unit hang over the end of the bench. Separate the cabinet from the base, making sure to clear the front edge of the keyboard. Lean the cabinet back onto its rear panel.

NOTE: Do not attempt to remove screws from base of unit by turning unit upside down as damage to front panel controls may result.

CAUTION - KEYBOARD PROTECTION
Before proceeding with further disassembly or servicing, care should be taken to protect keyboard from: -Scratches from solder spikes of printed circuit boards. -Chemical reaction of special cleaners or sprays to the plastic key parts. It is suggested that the keyboard be covered with a piece of soft foam or similar protective material during repair.



BOTTOM VIEW



REAR VIEW

CONNECTOR REMOVAL
Virtually all connections to the PC board are made with either CIS, MTA or RIBBON CABLE connectors. If it is necessary to remove any of these connectors during troubleshooting, do so by grasping the connector housing firmly and lifting upward. In the case of the CIS and MTA connectors, NEVER PULL ON THE WIRES. Remove the ribbon connector as you would an IC, by inserting a small screwdriver between the pins and prying with slight pressure. NEVER REMOVE A CONNECTOR FROM ITS SOCKET BY PULLING ON THE RIBBON CABLE.

REMOVING THE CONTOUR BOARD
To remove the CONTOUR BOARD, the keyboard must first be removed (see KEYBOARD REMOVAL).
With keyboard removed, locate the PC board mounting posts and lift the board up while slightly bending on the locking tab.

REMOVING THE DIGITAL BOARD
The DIGITAL BOARD is held in by four (4) screws. The rear screws attach the board to hinged standoffs. The DIGITAL BOARD is also attached by a tie-wrap to the COMMON ANALOG BOARD. Note the use of insulation (fish paper) on the trace side of the board.

REMOVING THE COMMON ANALOG BOARD
The COMMON ANALOG BOARD is held in by four (4) screws. The rear screws attach the board to hinged standoffs. The COMMON ANALOG BOARD is also attached by a tie-wrap to the DIGITAL BOARD. Note the use of insulation (fish paper) on the trace side of the board.

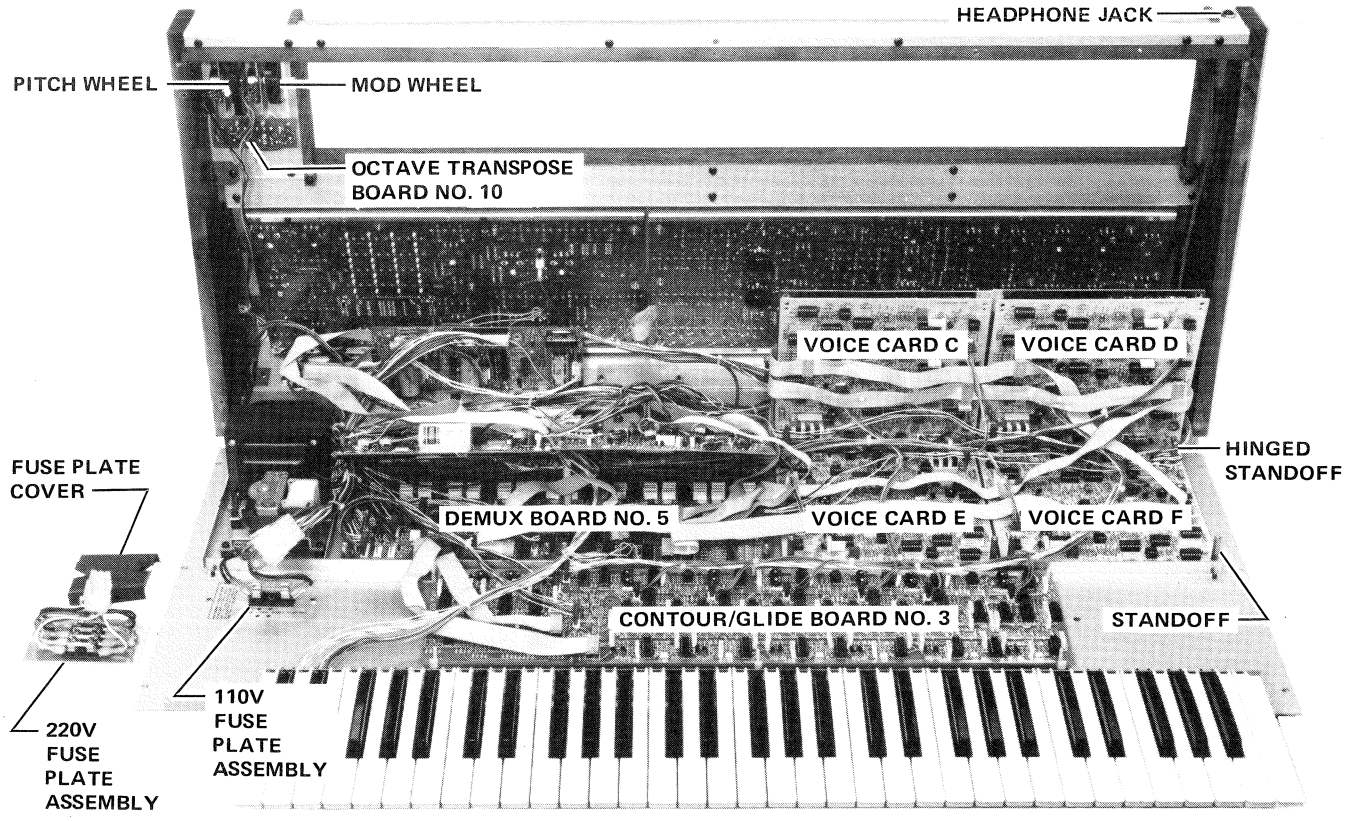
REMOVING DMUX BOARD
The DMUX BOARD is mounted below the DIGITAL and COMMON ANALOG BOARDS using four (4) standoffs. These two (2) boards must be removed to remove the DMUX BOARD.

If problem is isolated to the DMUX BOARD, components on this board may be replaced by removing the eight (8) mounting screws from the base and removing the entire three (3) board assembly as a unit.

REMOVING VOICE CARDS
There are six (6) VOICE CARDS mounted in a three layer "sandwich" formation. The two (2) top right-hand boards (VOICE CARDS A & B) are mounted back-to-back with the center two (2) boards (VOICE CARDS C & D) using four (4) screws. The two (2) rear screws attach the four (4) boards to hinged standoffs, spacers and fish paper.

VOICE CARDS E & F are mounted to the base of the unit. The top four (4) VOICE CARDS must be removed in order to remove these two (2) VOICE CARDS. VOICE CARD E is located at the center and VOICE CARD F is loaced on the right-hand side.

If a problem is isolated to either VOICE CARD E or F, components on these boards may be replaced by removing the eight (8) mounting screws from the base and removing entire six (6) board assembly.



DISASSEMBLED UNIT (FRONT VIEW)

REMOVING THE POWER SUPPLY
The POWER SUPPLY is attached to the rear panel with six (6) screws, four (4) of which are accessible from the rear of the unit and two (2) are accessible from the inside below the POWER SUPPLY PC board. Once the mounting screws are removed, remove the four (4) connectors and slip the subassembly out through the rear panel.

Troubleshooting of the POWER SUPPLY may be accomplished by placing it atop the DIGITAL/COMMON ANALOG BOARDS under a suitable insulating material.

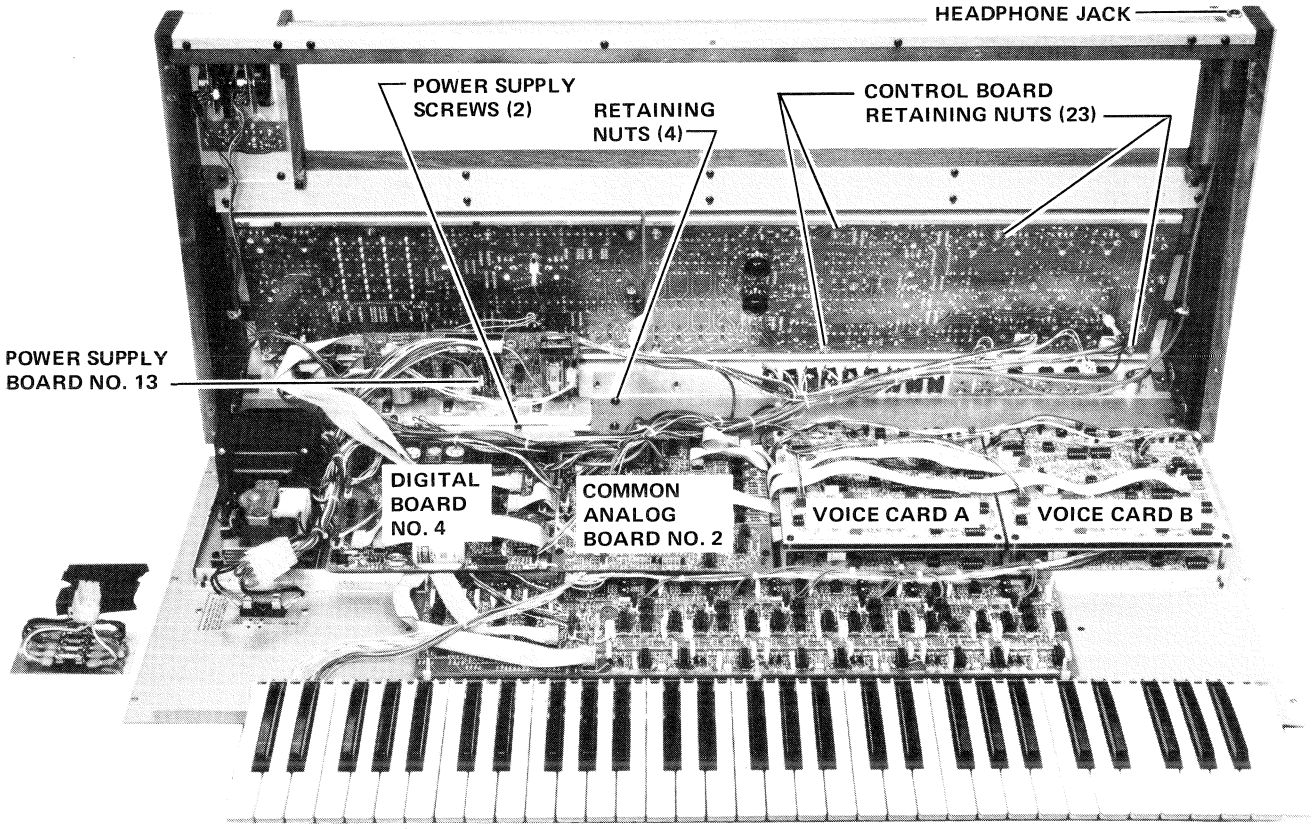
REMOVING FRONT PANEL
LEFT SIDE CONTROL BOARD (LSC)
It is recommended, for ease of service, to remove the POWER SUPPLY (See POWER SUPPLY removal) before attempting the removal of the LSC. Once the CONTROL BOARD is removed, it may be placed on the DIGITAL BOARD/COMMON ANALOG assembly using a cardboard separator or similar material.

The POWER SUPPLY may temporarily be reinstalled for unit servicing using the two (2) inside screws.

To remove the LSC board, remove the control knobs and the eleven 5/16" hex nuts, taking note of four (4) fiber washers used on earlier versions (approximately S/N 1400 and below).

RIGHT SIDE CONTROL BOARD (RSC)
This is accomplished by removing the control knobs. The FREQUENCY CONTROL for OSCILLATOR 2 and OSCILLATOR 3 requires a .050 and a 1/16" hex key wrench. Remove the twelve (12) 5/16" hex nuts.

NOTE: The LEFT and RIGHT SIDE CONTROL BOARDS are electrically connected together using two (2) ribbon cables. When reinstalling these boards make sure these cables lay flat against the PC board so as not to obstruct switch action.



DISASSEMBLED UNIT (FRONT VIEW)

SWITCH REMOVAL
The switch assembly is made up of four (4) components: the spring contact which is shown mounted on the PC board & soldered in place, the switch contact button (not shown in photo), the switch button or actuator, e.g. "D" and the return spring. The plastic button may be removed by using the handle end of a screwdriver and pressing it on the two (2) stems that protrude through the PC board. When re-installing the button use slight pressure to push the two (2) stems through the PC board insuring the spring is seated correctly and does not short against the switch contacts.

DISASSEMBLY AND REASSEMBLY (CONT'D)

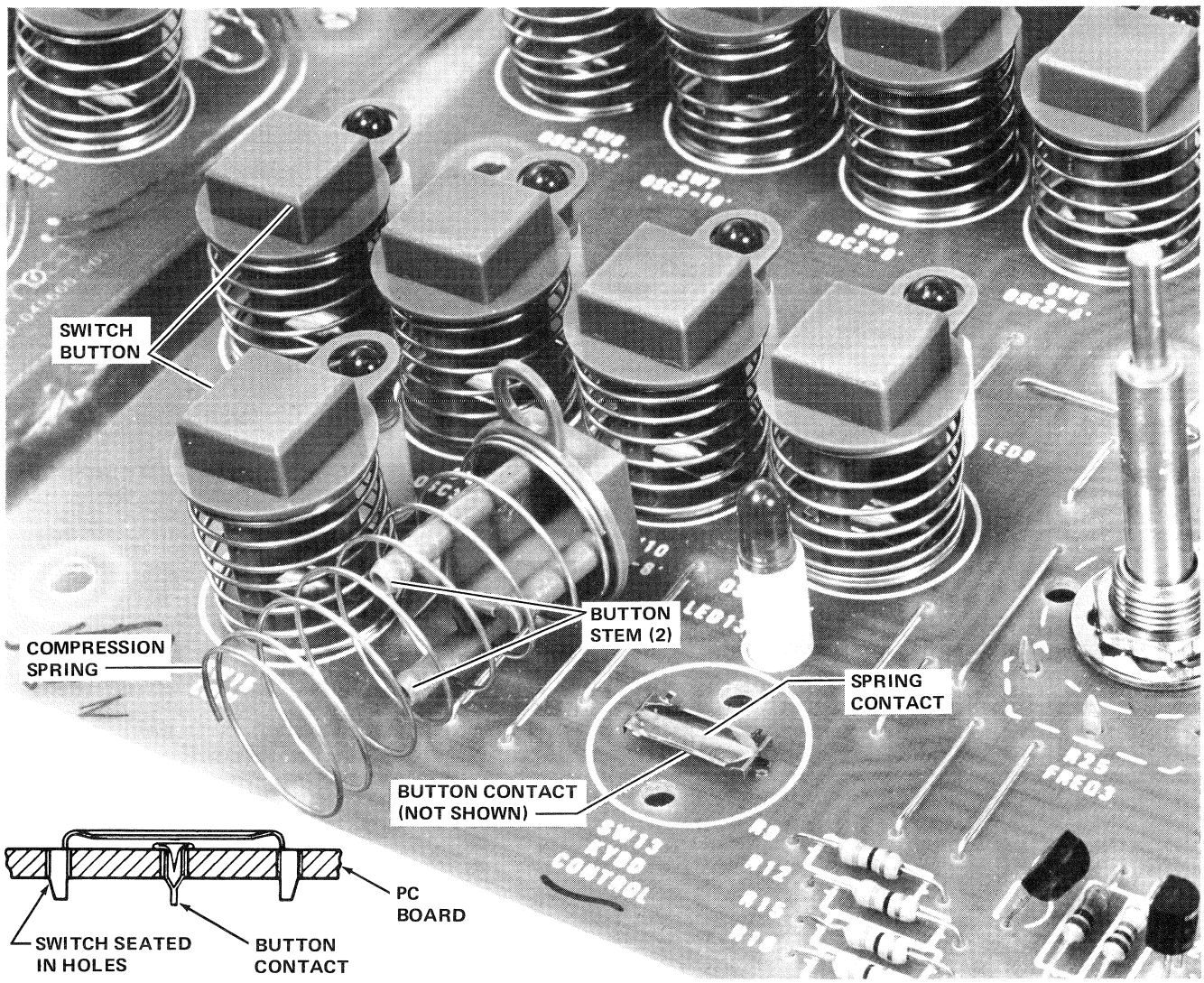
SWITCH CONTACT REPLACEMENT
If it is necessary to replace a spring contact switch or a contact button, extreme care must be taken when installing the new components.

The contact button is replaced by first removing the switch contact, then the contact button. The contact button must be seated against the PC board. The contact button may also be inserted using an AMP hand tool, model number 274262-1. The spring contact may be replaced using AMP tool number 274268-1 or by hand. When inserting by hand, use extreme caution and lightly press on each side-mounting pin of the contact until it is through the PC board. NEVER push the contact into the PC board by pressing on the CENTER of the spring contact as this will misshape it.

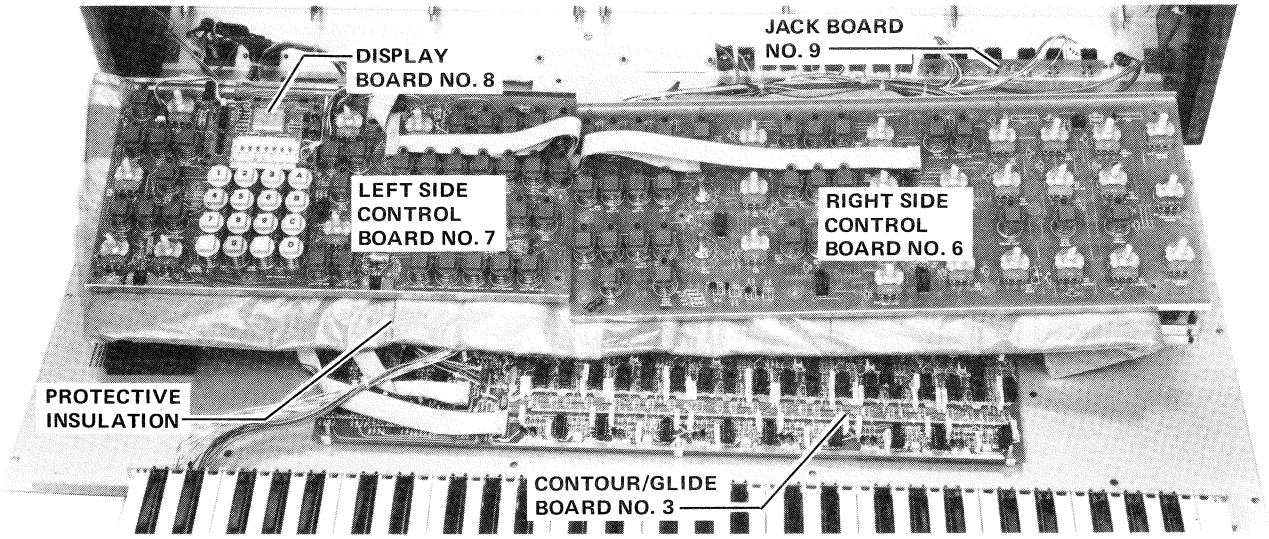
Note the accompanying insertion diagram.

REMOVING THE KEYBOARD
The keyboard is secured with six (6) screws accessible from the underside of the unit. The connector at the left rear of the keyboard assembly may also be disconnected for complete removal of the keyboard.

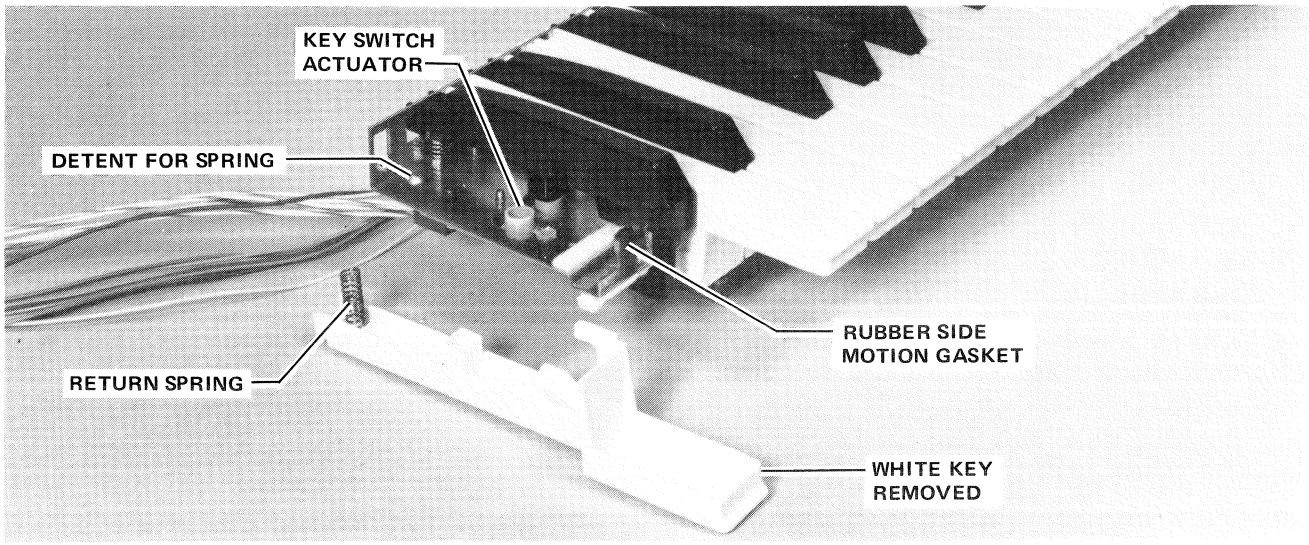
KEY REMOVAL
While holding the front end of the key and applying slight pressure to rear of the key, disengage the notches from keyboard frame noting that the key is held in not only by the notches but also by side pressure against the frame.



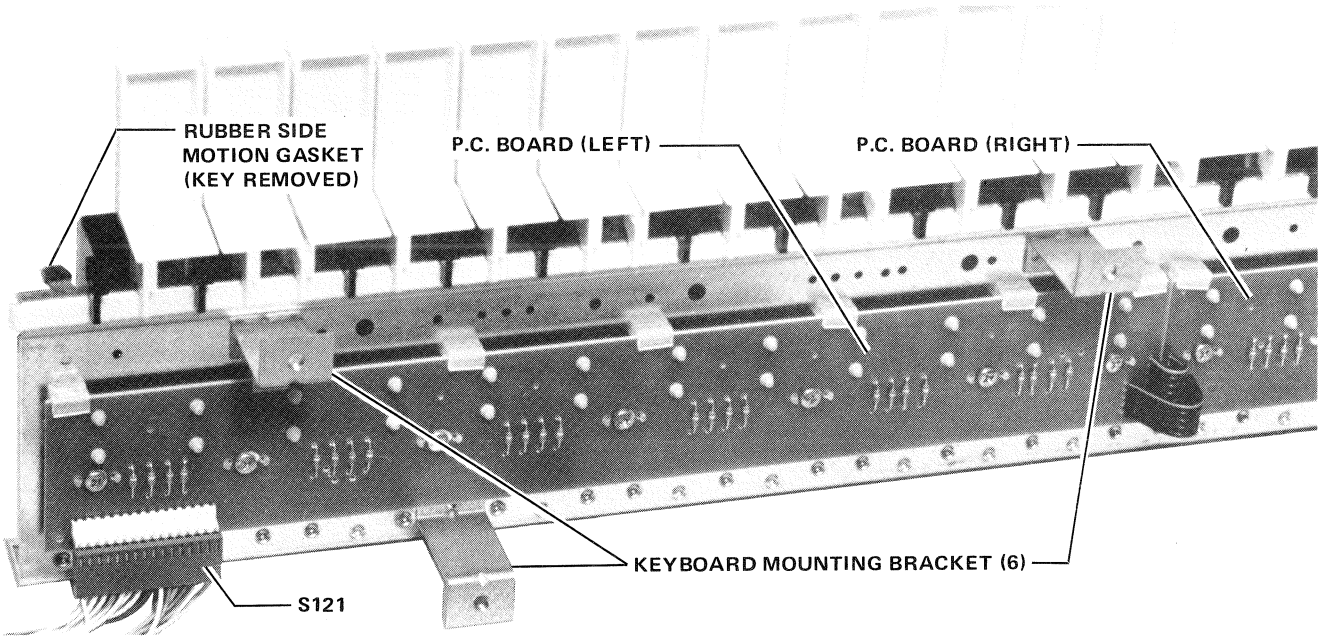
SWITCH CONTACT REPLACEMENT



DISASSEMBLED UNIT (FRONT VIEW)



KEYBOARD REMOVED (TOP VIEW)



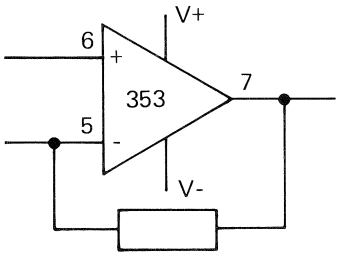
KEYBOARD REMOVED (BOTTOM VIEW)

TROUBLESHOOTING

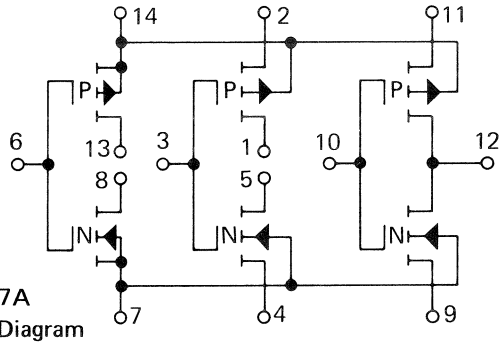
GENERAL
Many synthesizer repairs involve the replacement of integrated circuits. However, before replacing a suspect device, always double check the inputs and power supply terminals before proceeding. For any devices that are installed in sockets, thoroughly check each device for a possible "bent under" pin on the IC before proceeding with detailed troubleshooting of the circuit.

LINEAR IC
A linear IC with DC Input Offset measured between the + and - inputs should be no greater than 10mV apart or device is faulty.

Note in the accompanying diagram a typical IC used in a linear mode with negative feedback.

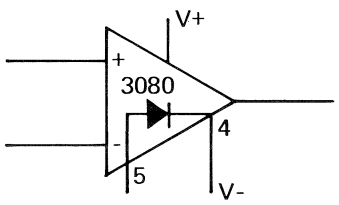


CMOS ICs
CMOS ICs usually fail by latching the output(s) and getting hot to the touch.



CD4007A
Functional Diagram
Terminal No. 7—V_{SS} Terminal No. 14—V_{DD}

OTA
Pin 5 of a 3080 type OTA should be 0.7V more positive than pin 4 when turned on. Troubleshoot it like a forward biased diode.



Use the charts provided on the following pages along with the circuit description and block diagrams to partition a problem, then, using the schematics and parts location information on the PC boards, final diagnosis and repair can be effected.

Once it is determined that an IC must be replaced, install the new one in a high quality IC socket. This will protect the printed circuit board in case further troubleshooting is necessary. Sometimes an IC known to be good can be used from another circuit to confirm a suspected problem.

NOTE: If the old IC is found to be good, put the old one back in. The old IC has more time in use and is therefore more reliable than a new IC of unknown performance.

Many faulty or shorted ICs will operate "hot" and can be detected with the "wet finger test".

POWER SUPPLY SUBASSEMBLY GENERAL SERVICING
The -15, +15 and +5 VDC outputs of the power supply subassembly must be checked first and adjusted to their nominal values within 10 millivolts prior to any equipment servicing. The most common anticipated problems related to the power supply subassembly are open recitifier diodes and transistors.

POWER SUPPLY SUBASSEMBLY TROUBLESHOOTING
Troubleshoot the power supply subassembly using the circuit description. Note that voltage levels displayed on the schematic diagrams are not absolute values as readings may vary between units. Once the problem is localized, check the suspected part by direct substitution if possible. Otherwise, use a voltmeter or oscilloscope to determine the malfunctioning part. Note the color code on the power supply schematics: +15V (red), -15V (black), +5V (yellow), ground (green).

TROUBLESHOOTING

CONNECTOR REPAIR AND REPLACEMENT
There are two basic types of connectors made by AMP in the MEMORYMOOG synthesizer. The first type is the Mass Termination Assembly (MTA) insulation displacement type connector.

The MTA 100 Series connector is based on .1 inch mounting centers pin spacing and is also color coded for a wire gauge. The red series MTA connectors in the MEMORYMOOG are to be used with only 22 gauge wire.

CAUTION
When disconnecting an MTA connector from a printed circuit board, be sure to firmly grip only the "connector housing" - NEVER disconnect it by pulling on the wire(s).

In order to properly repair an MTA connector in the field it should be replaced. First remove the old contact from the housing by poking a solder pick into the side "ramp" thereby freeing the contact. Next, install a new contact into the housing, cut off any damaged portion of the wire and proceed as follows:

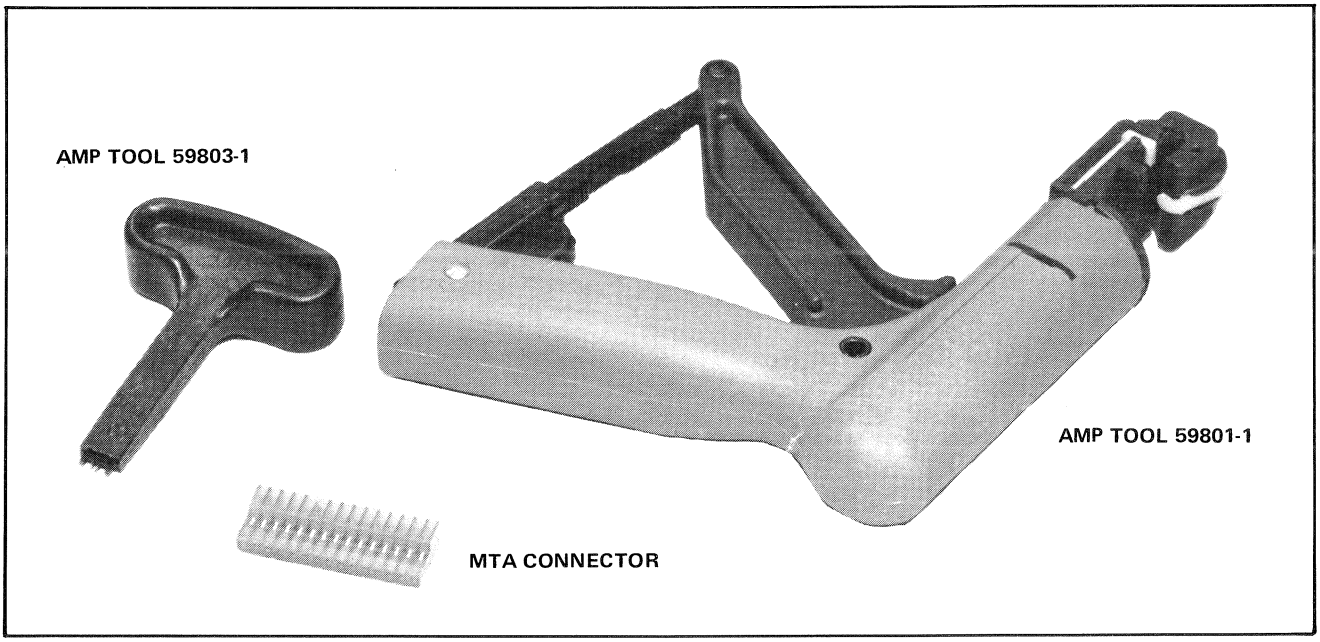
1. Use an AMP pistol insertion tool model 59801-1 and insert the housing from the left side. Placing the wire in the contact, secure it by tightening the tool handle or
2. Mount the housing into a heavy vise, insert the wire and press firmly into place by using the AMP hand tool, model 59803-1.

The second type of connector is the Commercial Interconnection System (C.I.S.) crimp socket which has 0.1 inch (2.5mm) mounting centers. This is a reliable connection system which can easily be replaced if necessary. The portion of the connector attached to the printed circuit board (header) is replaced by simply soldering a new one in place. Headers of 5, 6 or more pins can easily be cut using wire cutters to replace 1, 2, 3 or 4 pin versions. Simply score the header where the desired cut is to be made and cut the header appropriately. Refer to the accompanying illustrations.

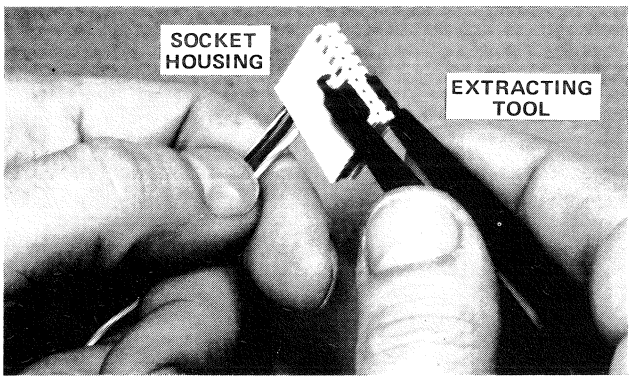
Headers which are causing poor or intermittent solder connections on a printed circuit board should be resoldered to ensure the best possible electrical and mechanical connection. If connector plating problems are suspected, use an extra activated multicore solder such as 0.064 diameter ERSIN No. 782/745 solder and a 40 watt soldering iron.

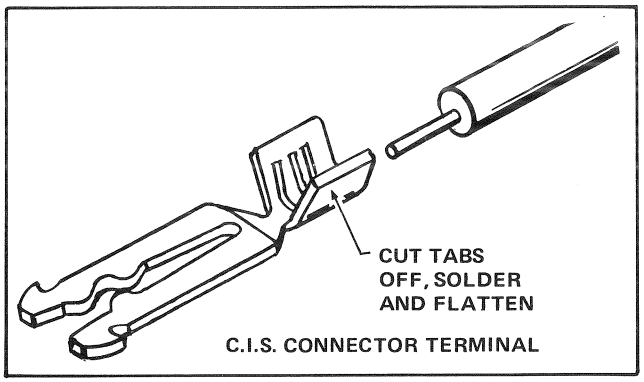
NOTE: BE SURE TO AVOID LONG EXPOSURE OF THE IRON TO THE PRINTED CIRCUIT BOARD TRACES AND TO CLEAN THE ACTIVATED FLUX RESIDUE FROM THE PRINTED CIRCUIT BOARD AFTER SOLDERING IS COMPLETE. RECOMMENDED FLUX CLEANER IS MILLER-STEPHENSON MS-190HD, "HEAVY DUTY FLUX REMOVER" OR A METHYL ETHYL KEYTONE PRODUCT.

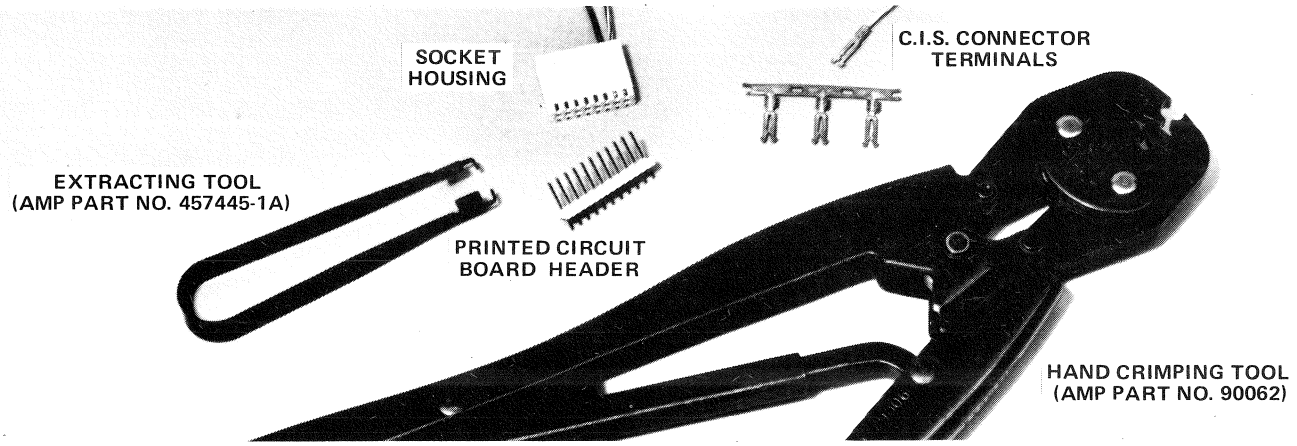
Replacement of the female C.I.S. connector terminal is sometimes necessitated if a wire breaks at the crimp within the socket. The spring loaded terminal may be removed using an AMP Extracting Tool, AMP Part No. 457445-1A or by inserting two pointed instruments into each side of the socket allowing a particular terminal to be pulled out or pushed out using an existing header pin or 1/4 watt resistor lead. The new terminal may be attached to the wire by using an AMP Hand Crimping Tool, AMP Part No. 90062, or by cutting the tabs off the new terminal and tack soldering it to the appropriate wire which has been stripped back 5/32 inch (3.9mm). The soldering must be neat and flattened with needle-nose pliers to ensure an easy fit into the connector housing.



MTA CONNECTOR, REPAIR AND REPLACEMENT







CIS CONNECTOR, REPAIR AND REPLACEMENT

POWER SUPPLY TROUBLESHOOTING GUIDE

SYMPTOM	CAUSE/REMEDY
1. Apply primary power to MEMORYMOOG and connect voltmeter negative test lead to "-" side of C74 on DMUX board and and positive test lead to "+" side of C74. Observe digital voltmeter and adjust +15 VDC trim pot R19 on power supply assembly for +15 VDC +/-10mv.	If proper voltage is present proceed to step 2. If output voltage is not present or cannot be adjusted disconnect power supply output connector and measure voltage between pins 7 (+) and 9 (-). If present, perform step 4. If not present, trouble is in power supply assembly.
2. Connect positive test lead to "+" side of C73 on DMUX board. Observe digital voltmeter and adjust +5 VDC trim pot R33 on power supply assembly for +5 VDC +/-10 mv.	If proper voltage is present, proceed to step 3. If output voltage is not present or cannot be adjusted disconnect power supply output connector and measure voltage between pins 14 (+) and 12 (-). If present, perform step 4. If not present, trouble is in power supply assembly.
3. Connect positive lead to "-" side of C75 on DMUX board. Observe digital voltmeter and adjust -15 VCD trim pot R8 on power supply assembly for -15 VDC +/-10mv.	If proper voltage is present, power supply assembly is operating properly. If output voltage is not present or cannot be adjusted disconnect power supply output connector and measure voltage between pins 4 (-) and 2 (+). If present, perform step 4. If not present, trouble is in power supply assembly.
4. Reconnect power supply output connector and digital voltmeter test leads to pins on DMUX BOARD where proper voltage was not available.	Monitor digital voltmeter sequentially disconnect power supply input connectors on the printed circuit boards until voltage indication appears (shorted board located). Troubleshoot or repair board as outlined in the applicable section. If voltage indication still is not present, trouble is in cable harness.
5. Loss of all output voltages.	Power source, power cord, power switch, fuses and T1.

POWER SUPPLY TROUBLESHOOTING GUIDE (CONT'D)

SYMPTOM	CAUSE/REMEDY
6. -15 VOLT SUPPLY - Loss of -15V output voltage.	Voltage buss external to power supply shorted to common, P132, CR1 thru CR4, Q1, Q2, IC1, R8, P131 and C3.
Voltage at pin 6 of IC1 is not -7.85 +/-0.39V or voltage at pin 10 is less than -1.62V.	IC1, C1, R2 thru R4, R6 and and R10.
Loss of -15V output adjustment.	R10, R7 thru R9.
Excessive -15V output voltage, no voltage control.	Q1, Q2 and IC1.
Low -15V output voltage.	CR1 thru CR4, instrument wiring shorted (power supply in current limiting).
7. +15 VOLT SUPPLY Loss of +15V output voltage.	Voltage bus external to power supply shorted to common, P133, CR8 thru CR11, Q3, Q4, IC2, R19, P131 and C6.
Voltage at pin 6 of IC2 is not +7.15 +/-0.36V or voltage at pin 10 is less than +16.7V.	IC2, C4, R13 thru R15, R17, R21, CR12 and C6.
Loss of +15V output adjustment.	R18 thru R21.
Excessive +15V output voltage, no voltage control.	Q3, Q4 and IC2.
Low +15V output voltage.	CR8 thru CR11, instrument wiring shorted (power supply in current limiting).
8. +5 VOLT SUPPLY Loss of +5V output voltage.	Voltage bus external to power supply shorted to common, P3, CR15 thru CR18, Q5 thru Q7, IC3, R33, P4 and P9.
Voltage at pin 6 of IC3 is not +7.15 +/-0.36V or voltage at pin 10 is less than +7.32V.	IC3, C7, R35, R24 thru R28, R30, R31, CR19 and C9.

POWER SUPPLY TROUBLESHOOTING GUIDE (CONT'D)

SYMPTOM	CAUSE/REMEDY
8. (CONT'D)	
Loss of +5V output adjustment.	R33 thru R35.
Excessive +5V output voltage, no voltage control.	Q5 thru Q7 and IC3.
Low +5V output voltage.	CR15 thru CR18, instrument wiring shorted (power supply in current limiting).

VOICE CARD TROUBLESHOOTING GUIDE

The MEMORYMOOG has a software routine to isolate defective VOICE CARD OSCILLATORS. Depress the AUTOTUNE button and observe the display. In 5 to 10 seconds, the display will show "X tuned", where X is the number of usable voices. X will equal 6 if all VOICE CARDS are good. If X is less than 6, faulty VOICES can be isolated as follows:

1. Depress "C7" followed by "ENTER" twice.
2. The display will show "VOICE ?".
3. Depress any VOICE number (1 through 6) desired to be tested, where VOICE A = 1, VOICE B = 2, etc.
4. After about 1 second the display will show "OSC ?".
5. Depress any oscillator number (1 through 3) desired to be tested.
6. The display has a flashing format.

"DEAD OSC" or numbers indicating the AUTOTUNE voltages for the OSCILLATOR in a hexideximal code. Nominal values of 7F HEX would indicate all three oscillators are close in value to each other. Refer to the software tuning section for further information.

INDIVIDUAL VOICE CARD TROUBLESHOOTING

SYMPTOM	CAUSE/REMEDY
1. One of the three OSCILLATORS is dead, or waveforms are missing.	Check for 10 volt waveforms (PULSE, SAWTOOTH, TRIANGLE) at: Osc. 1,U3 (4016) Pins 1,4 & 8 Osc. 2,U7 (4016) Pins 1,4 & 8 Osc. 3,U10(4016) Pins 1,4 & 8
2. NO waveforms present from Step 1.	Faulty (3340) VCO or (4558) Osc. 1, U1(3340), U2 (4558) Osc. 2, U5(3340), U6 (4558) Osc. 3, U8(3340), U9 (4558)
3. ALL waveforms present from STEP 1.	Check for proper switching of the waveforms (PULSE, SAW-TOOTH, TRIANGLE) at: Osc. 1,U3 (4016) Pins 2,3 & 9 Osc. 2,U7 (4016) Pins 2,3 & 9 Osc. 3,U10(4016) Pins 2,3 & 9 Use the FRONT PANEL WAVEFORM switches to enable the individual waveforms & proceed to Step 5.

VOICE CARD TROUBLESHOOTING GUIDE (CONT'D)

SYMPTOM	CAUSE/REMEDY
4. TRIANGLE waveform and/or PULSE wave missing from STEP 1 sawtooth.	Osc. 1, U2 Faulty (4558) Osc. 2, U6 Faulty (4558) Osc. 3, U9 Faulty (4558)
5. One or more waveforms not switching from STEP 3.	Check +15V enable inputs on: PULSE Pin13/Osc 1,U3 (4016) SAWTOOTH Pin 5/Osc 2,U7 (4016) TRIANGLE Pin 6/Osc 3,U10(4016)
6. OSC. 1 AND 2 dead but OSC. 3 is OK.	Faulty (3360) VCA, U4.
7. OSC. 3 is dead but OSC 1 & 2 are OK.	Faulty (3360) VCA, U13.
8. OSC. 1, 2 & 3 are dead but NOISE works.	Check for output on U12, Pin 1, (353/TL072). Replace if no output or latched at +15V or -15V. Signal may approach approximately 16V peak to peak, with associated mixer controls at maximum.
9. OSC. 1, 2, 3 & NOISE are ALL dead. Note: This normally indicates a VCF and/or VCA problem.	A) Observe input signal to VCF at "+" side of C26. This has a 40mV p-p small signal superimposed on a +1.37V DC level. B) Set front panel CUTOFF to maximum and EMPHASIS to minimum. C) The AC signal of STEP A should appear differentially on the output of the VCF ladder, U20 Pins 3 and 5. If signal is present, proceed to to STEP 12.
10. No VCF output from STEP 9C. This narrows the problem to either the VCF ladder or current source.	Bypass the VCF current source by shorting collector 2 of Q14 to ground (Base 2 of Q14). This forces the VCF wide open. If there is still no signal present at U20 pins 3 & 5, proceed to STEP 13.
11. Signal is present from STEP 10. Problem is in current source. U19, Q4, R173 through R176.	A) Remove short from Q14 (STEP 10) and place a jumper across R175 & observe signal at U20, Pins 3 & 5. B) If signal is still present, check DC voltage at U19 Pin 1 and replace if voltage is latched at +14V or -14V. C) If no signal is present from STEP 11A, check DC voltage at U19 Pin 6 for zero volts.

VOICE CARD TROUBLESHOOTING GUIDE (CONT'D)

SYMPTOM	CAUSE/REMEDY
11. (CONT'D)	D) If Pin 6 is zero, replace Q14. E) If Pin 6 is positive, jump Q14 Collector 1 to Collector 2 and recheck voltage at U19 Pin 6. F) If voltage is now zero, replace Q14: if voltage is not zero, replace U9.
12. VCF recovery amp.	Replace U20 (353 IC) if there is no signal on Pins 1 & 7. If signal is present, go to STEP 14.
13. VCF ladder problem.	A) Check for DC voltage balance of less than 0.1V difference between the emitters of the following transistor pairs; Q9-10, Q7-8, Q5-6 and Q14 Emitter 1 to Emitter 2. B) Replace any out of tolerance pairs. C) Go back to STEP 10 if any transistors were replaced. D) Replace C28 through 31 and go back to STEP 10. E) Check DC voltages on: Q11, Base 1 & 2; +1.4V Base of Q9 & 10; +2.7V Base of Q7 & 8; +4.1V Base of Q5 & 6; +5.5V Base 1 & 2 of Q4; +6.9V Replace bias network N2 if voltages deviate greatly from above and go to STEP 10. F) Replace all transistors Q4 through Q11 NOT replaced in STEP 13B and go to STEP 10.
14. VCA problem.	A) Check for about 40mv of signal on U22 pins 2 & 3. Go to STEP 12 if signals are not present. B) Short Q13 collector to ground (BASE) and check for signal on U22 Pin 6. Replace U22 if no signal is present. C) Replace Q13 if signal is present.
15. Emphasis problem.	A) Verify VCF is working STEP 9 and 12. B) Short Q12 collector to ground and check VCF at U20 Pins 1 and 7 for sine wave oscillation. C) If no oscillation is present replace U20 and go to STEP 15B. D) Replace C28 through 31 and go to STEP 15B. E) Replace Q12.

MEMORYMOOG CALIBRATION PROCEDURE

INTRODUCTION

Most of the adjustments below are interdependent procedures which MUST be performed in the order presented, however, normal oscillator recalibration WILL NOT require all steps to be performed.

The Memorymoog PROMs have a considerable amount of diagnostic software built in, therefore, try the SOFTWARE TUNING procedure FIRST and the test equipment procedure only as necessary. The replacement of an IC that has an associated trim potentiometer will require recalibration, except that the replacement of a 3340 oscillator IC may ONLY require SOFTWARE oscillator TUNING - again try the SOFTWARE TUNING FIRST!

THE SOFTWARE OSCILLATOR TUNING OUTLINE

- Find the out-of-tune oscillator(s).
- Note the AUTOTUNE parameters and perform minor recalibration where necessary.
- Perform major osc recalibration.

LOCATING THE OUT-OF-TUNE VOICE(S) AND OSCILLATOR(S)

- Hit 2, ENTER for the straight brass program #2.
- Hit KB MODE, 1 and ENTER to put the Memorymoog into the "POLY 1" mode (cyclic mode). The display will read "EDIT".
- Hit C, 5 and ENTER to electrically center the oscillator frequency settings of oscillators 2 and 3 (unison). The display will read "FREQ CTR".
- Hit C, 4 and ENTER and listen for an out-of-tune voice (rapid beating sound) by repeatedly playing the high C key. The display will initially read "DEFEAT ?" and then will indicate the voice being played, "1", "2", etc. WRITE DOWN THE OUT-OF-TUNE VOICE NUMBER!

For any out-of-tune voice, isolate and listen to each OSCILLATOR by turning on and off the individual waveform switches (SAWTOOTH) for oscillators 1, 2 & 3. This will locate the out-of-tune oscillator - WRITE DOWN THE OSCILLATOR NUMBER!

NOTING THE AUTOTUNE PARAMETERS

- Hit C, 7, ENTER and ENTER again; the display will then query "VOICE ?"; hit the number of the voice above, which was out-of-tune, BUT DO NOT HIT ENTER!; Wait a second and the display will then query "OSC ?"; hit the number of the oscillator above which was out-of-tune but, again, DO NOT HIT ENTER; the display will then flash an expanded scale version of the AUTOTUNE voltages in a hexidecimal (HEX) format indicating from left to right a two digit RANGE, SCALE and HIGH TRIM code.

- WRITE THESE VALUES DOWN with associated voice and oscillator numbers from above. Note that the second digit may "bobble" +/- one digit. An "ideally" tuned oscillator would display 7F 7F 7F. See the accompanying hexidecimal chart.

"DEAD OSC"
The AUTOTUNE voltages will flash so long as the oscillator is tuned within a +/- 50c range. However, if the oscillator's tuning is outside this capture range, the display will indicate "DEAD OSC". The oscillator usually is not dead but simply outside the AUTOTUNE range. See the MAJOR OSCILLATOR RECALIBRATION section of this procedure.

- A MINOR RANGE ADJUSTMENT. If the SCALE and HI are within +/- 2 digits of the RANGE, but the RANGE is too far from the 7F nominal value, a simple range adjustment is all that is necessary. * indicates the trim being adjusted in the example.

EXAMPLE:	VOICE 1	OSC 1
52*	54	53
RANGE	SCALE	HI

A difference of 1 or 2 between these values means the oscillator is close enough in SCALE and HIGH TRIM but its RANGE is too low.

EXAMPLE:	VOICE 1	OSC 1
7F*	81	80
RANGE	SCALE	HI

Readjustment of the RANGE to the 7F nominal value also brings the SCALE and HIGH TRIM to acceptable values. RANGE trim note: to INCREASE the RANGE readings, turn OSC 1 & 2 RANGE trims COUNTER-CLOCKWISE and OSC 3 RANGE trim CLOCKWISE.

- TOUCH-UP TUNING. Complete readjustment will be necessary if there are differences between the three oscillator values exceeding +/- 2 DIGITS. Below is an example of this condition. * indicates the trim being adjusted in the example.

EXAMPLE:	VOICE 1	OSC 1
A3	9E*	94
RANGE	SCALE	HI

These oscillator values are very far apart; first adjust the SCALE to approximately EQUAL the RANGE. (Note that the SCALE trim affects the RANGE and HI). SCALE trim note: To INCREASE the "SCALE" readings, turn OSC 1 & 3 SCALE trims CLOCKWISE and OSC 2 SCALE COUNTER-CLOCKWISE.

EXAMPLE:	VOICE 1	OSC 1
C1	C3	B0*
RANGE	SCALE	HI

Next adjust the TRIM to approximately EQUAL the RANGE and SCALE. HI trim note: To INCREASE the "HI" readings, turn, OSC 2 & 3 HI trims CLOCKWISE and OSC 1 HI trim COUNTER-CLOCKWISE.

EXAMPLE: VOICE 1 OSC 1

C1*	C3	C1
RANGE	SCALE	HI

Lastly adjust the RANGE to the nominal value of 7F and the other adjustments will follow automatically.

EXAMPLE: VOICE 1 OSC 1

7F	81	7F
RANGE	SCALE	HI

This is the end of the software adjustment procedure for minor VOICE/OSCILLATOR recalibration. If it is necessary to proceed to identify other out-of-tune voices and/or oscillators, depress and "hold" the ENTER switch until the display reads "ENTER"; then hit ENTER again and the display will inquire as above for which VOICE and oscillator to display. An ENTER instruction will not be accepted if the flashing display is in an unlit state. To exit this mode of operation, hit ENTER when the display queries "VOICE?".

- MAJOR OSCILLATOR RECALIBRATION. Oscillators for which the display indicates "DEAD OSC" can be brought into range "by ear" using a tuned oscillator of the same VOICE as a reference source assuming the oscillator is simply out of the AUTOTUNE capture range.

This procedure will be required for a 3340 VCO replacement or for troubleshooting a suspected VCO that is swapped on a VOICE CARD to confirm tuning instability.

- Defeat all voices EXCEPT the one to be recalibrated. If, for example, VOICE 1 is out-of-tune, the following routine will defeat the other VOICES (2 through 6):

C, 4, ENTER "DEFEAT ?", 2 ENTER
C, 4, ENTER "DEFEAT ?", 3 ENTER
C, 4, ENTER "DEFEAT ?", 4 ENTER
C, 4, ENTER "DEFEAT ?", 5 ENTER
C, 4, ENTER "DEFEAT ?", 6 ENTER

This allows repeated notes to be played in the cyclic mode (POLY MODE 1) with only the out-of-tune oscillator showing in the ALPHANUMERIC DISPLAY.

- Hit 2, ENTER for the straight brass PROGRAM #2.
- Hit 4 foot OCTAVE for oscillators 1, 2 & 3.
- Hit C, 6, ENTER to clear out previous AUTOTUNE voltages.
- Hit C, 5, ENTER for a unison sound.
- Hit C, 4, ENTER and repeatedly play the high C key. Note that the ALPHANUMERIC display should ONLY show the VOICE to be recalibrated. If not, go back to the defeat routine above.
- Using the waveform selection switches (in this case, the SAWTOOTH switches), compare the out-of-tune oscillator with ONE of the good oscillators - the second good oscillator should be turned off.
- Hold down the low A (A1) and adjust the associated RANGE trim for unison.
- Hold down the MIDDLE (third) A (A3) and initially adjust the associated SCALE trim for "unison" but note the number of turns needed for unison (example: three turns clockwise). The SCALE trim significantly interacts with the RANGE trim, therefore, "overshoot" this SCALE trim by twice the number of turns (example: additional turns clockwise). Repeat the six RANGE and SCALE adjustments until both the low, and middle A notes will zero beat.
- Hold the High A (A5) and adjust the associated HI trim for zero beats.

Refer to the TOUCH UP tuning procedure above for further minor adjustments if the oscillator will not autotune. When this tuning procedure is completed, hit C4, ENTER, ENTER to ENABLE all six voices. The display will then indicate "ENABLE".

	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
	10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F
	20	21	22	23	24	25	26	27	28	29	2A	2B	2C	2D	2E	2F
	30	31	32	33	34	35	36	37	38	39	3A	3B	3C	3D	3E	3F
	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F
	50	51	52	53	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F
	60	61	62	63	64	65	66	67	68	69	6A	6B	6C	6D	6E	6F
#	70	71	72	73	74	75	76	77	78	79	7A	7B	7C	7D	7E	7F*
	80	81	82	83	84	85	86	87	88	89	8A	8B	8C	8D	8E	8F
	90	91	92	93	94	95	96	97	98	99	9A	9B	9C	9D	9E	9F
	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	AA	AB	AC	AD	AE	AF
	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	BA	BB	BC	BD	BE	BF
	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	CA	CB	CC	CD	CE	CF
	D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	DA	DB	DC	DD	DE	DF
	E0	E1	E2	E3	E4	E5	E6	E7	E8	E9	EA	EB	EC	ED	EE	EF
	F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	FA	FB	FC	FD	FE	FF

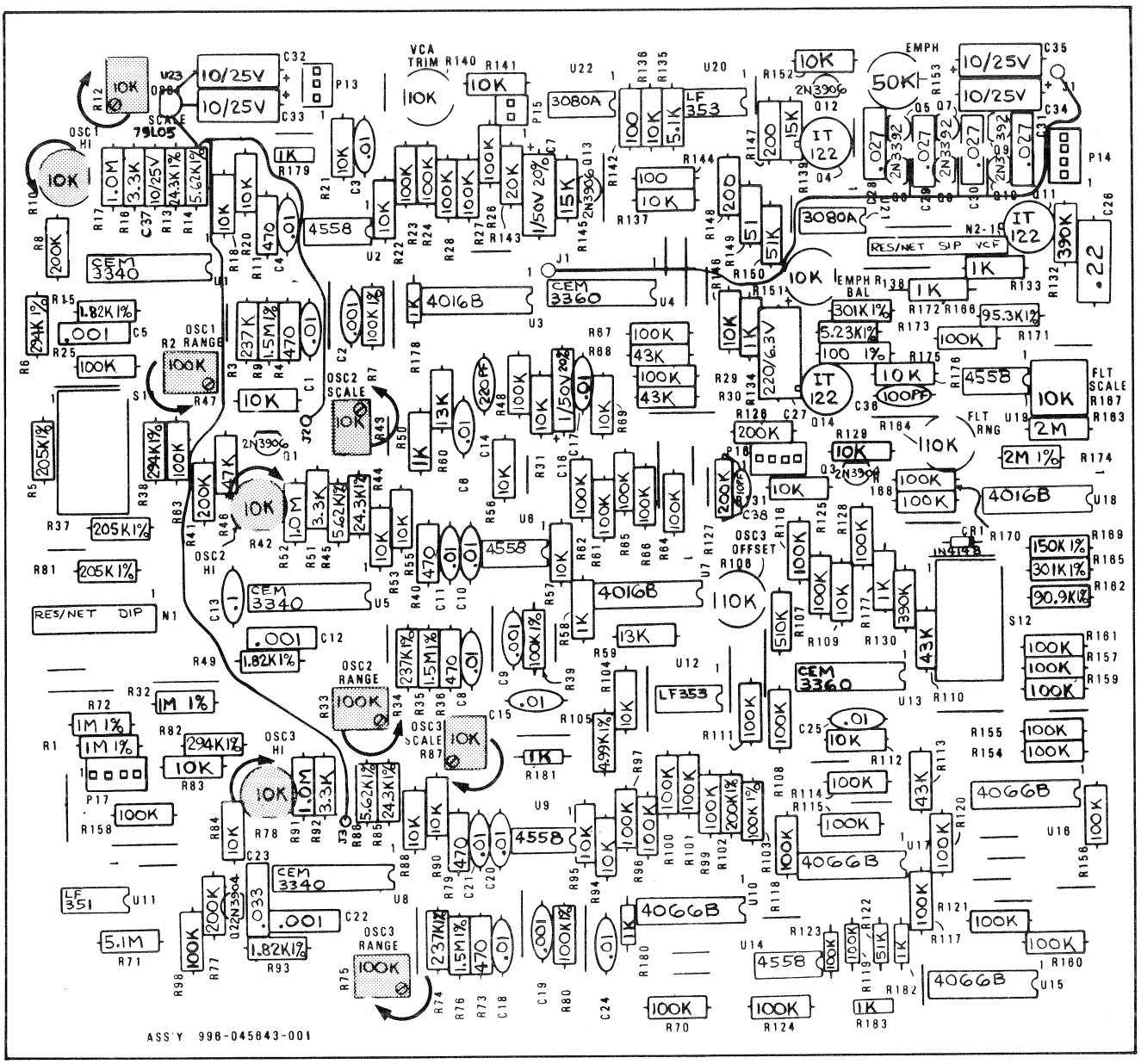
NOMINAL CAPTURE RANGE OF THE AUTOTUNE CIRCUIT IS FROM 70 HEX TO 8F HEX FOR THE RANGE.

* NOMINAL ADJUSTMENT VALUE - 7F

HEXIDECIMAL AUTOTUNE CHART

HEXIDECIMAL OSCILLATOR TUNING PARAMETERS

		FIRST READING	SECOND READING	THIRD READING
V/C	OSC			
1	1	— — —	— — —	— — —
	2	— — —	— — —	— — —
	3	— — —	— — —	— — —
2	1	— — —	— — —	— — —
	2	— — —	— — —	— — —
	3	— — —	— — —	— — —
3	1	— — —	— — —	— — —
	2	— — —	— — —	— — —
	3	— — —	— — —	— — —
4	1	— — —	— — —	— — —
	2	— — —	— — —	— — —
	3	— — —	— — —	— — —
5	1	— — —	— — —	— — —
	2	— — —	— — —	— — —
	3	— — —	— — —	— — —
6	1	— — —	— — —	— — —
	2	— — —	— — —	— — —
	3	— — —	— — —	— — —



INDICATES INCREASE

VOICE CARD

ABBREVIATED OSCILLATOR TUNING WITH EQUIPMENT

Using test equipment, a shortened oscillator tuning procedure may be accomplished as follows:

Perform POWER SUPPLY, DMUX and PRELIMINARY OSCILLATOR TUNING (Steps I, II and III); omit the next four steps - preliminary CONTOUR/GLIDE, preliminary COMMON ANALOG, FILTER tuning and VCA balance (Steps IV, V, VI and VII) -unless an associated part has been replaced; proceed with MAIN OSCILLATOR TUNING (Step VIII), MONOPHONIC SCALING adjustments (Step IX) and LHC + OCTAVE TRANSPOSE (Step X). Therefore, abbreviated oscillator tuning consists of only Steps I, II, III, VIII, IX and X.

The remaining adjustments, such as MODULATION OSCILLATOR (Step XI), PITCH WHEEL offset (Step XII), VOICE MODULATION offset (Step XIII) and FOOT PEDAL adjustments (Step XIV) can all be skipped unless associated parts have been replaced.

NOTE:
NOTE: When performing MAIN OSCILLATOR tuning Step VIII be aware that the SCALE trim SIGNIFICANTLY offsets the RANGE trim. To expedite tuning time, "over-shooting" the SCALE trim by factor of two in the opposite direction speeds tuning, eg. if the SCALE is 10c flat, turn the SCALE adjustment approximately 20c sharp.

MEMORYMOOG CALIBRATION PROCEDURE (CONT'D)

WARMUP AND ACCURACY
Turn power on and allow unit to warm up at least ten minutes before attempting calibration. Use of a 4-1/2 digit DVM is NECESSARY for accurate calibration.

I. POWER SUPPLY ADJUSTMENTS
-15V SUPPLY ADJUSTMENT (4-1/2 DIGIT DVM REQUIRED)
1. Attach the negative DVM probe to the negative side of C74 and the positive probe to the negative side of C75, both on the DMUX board.
2. Adjust R8 on the POWER SUPPLY board for 15.000 volts.

+15 VOLT SUPPLY ADJUSTMENT (4-1/2 DIGIT DVM REQUIRED)
1. Attach the positive lead of the DVM to the plus side of C74 on the DMUX board.
2. Adjust R19 on the POWER SUPPLY board for 15.000 volts.

+5 VOLT SUPPLY ADJUSTMENT
1. Attach the plus lead of the DVM to the positive side of C73 on the DMUX board.
2. Adjust R33 on the POWER SUPPLY board for 5.000 volts.

II. DMUX BOARD ADJUSTMENTS
+10 VOLT DAC REFERENCE ADJUSTMENT (4-1/2 DIGIT DVM REQUIRED)
1. Attach the DVM positive lead to the P518 side of R5 on the DMUX board.
2. Adjust R4 on the DMUX board for 10.000 volts.

DAC ZERO OUTPUT ADJUSTMENT
1. Attach the plus side of the DVM probe to the far side of R67 on the DMUX board.
2. Depress the 16' octave switch of OSCILLATOR 1.
3. Adjust R10, (DAC ZERO trim) on the DMUX board for 0.000 volts.

DAC FULL SCALE ADJUSTMENT (4-1/2 DIGIT DVM REQUIRED)
1. Depress the 2' OCTAVE switch on OSCILLATOR 1.
2. Adjust R8, the DAC FULLSCALE trim on the DMUX board to 10.000 volts.

III. PRELIMINARY OSCILLATOR TUNING FRONT PANEL SET-UP
1. Attach the DVM positive lead to the wiper of the TUNE pot and set the TUNE pot for 0.00V +/- 10mV.
2. Set up FRONT PANEL controls in Fig. 1.
3. Enter POLYPHONIC KEYBOARD MODE I by depressing "KB MODE", "1" and ENTER.
4. Electrically center Frequency 2 and Frequency 3 by depressing "C", "5" & ENTER.
5. Defeat AUTOTUNE by depressing "C", "6" & ENTER.
6. Remove keyboard from unit but do not disconnect keyboard wire harness.

IV. PRELIMINARY ADJUSTMENTS - CONTOUR/GLIDE
1. Attach DVM positive lead to the U2, Pin 7 side of R56 on the CONTOUR/GLIDE board.
2. Depress "MONO" button to turn it ON.
3. Depress the lowest note on the keyboard.
4. Adjust R53 for 0.000 volts.
5. Depress "MONO" button to turn it OFF.
6. Hold highest note on keyboard and depress and release "HOLD" button.
7. Release highest note.
8. Adjust R60 (TRANSPOSE SCALE I) on CONTOUR/GLIDE board for 0.000 volts.
9. Depress "HOLD" button to turn OFF.
10. Repeat Step 2 thru 9 if necessary to achieve 0.000 volts with no further adjustments.

V. PRELIMINARY ADJUSTMENTS - COMMON ANALOG
1. Attach DVM to Pin 7 on U15 on the COMMON ANALOG board.
2. Adjust R102 for 0.000 Volts.
3. Attach DVM to U16 Pin 7.
4. Adjust R111 for 0.000 Volts.
5. Attach DVM to U17 Pin 7.
6. Adjust R123 for 0.000 Volts.
7. Depress "MONO" switch to turn in ON.
8. Hit highest note on keyboard.
9. Adjust R136 for 4.708 volts with a 4-1/2 digit DVM.
10. Attach DVM to U16 Pin 7.
11. Adjust R120 for 4.708 volts with a 4-1/2 digit DVM.
12. Attach DVM to U15 Pin 7.
13. Adjust R107 for 4.708 volts with a 4-1/2 digit DVM.
14. Depress "MONO" button to turn it OFF.
15. Depress 2' range on all OSCILLATORS and hit highest note on keybaord.
16. Adjust R104 for 2.828 volts with a 4-1/2 digit DVM.
17. Attach DVM to U16 Pin 7.
18. Adjust R114 for 2.828 volts with a 4-1/2 digit DVM.
19. Attach DVM to U17 Pin 7.
20. Adjust R125 for 2.828 volts with a 4-1/2 digit DVM.
21. Set all OCTAVE switches to 4'.

VI. FILTER TUNING
FILTER SCALE, RANGE & EMPHASIS ADJUSTMENT

1. Set FRONT PANEL controls as in Fig. 2.
2. Attach 400F A.C. voltmeter or equivalent, Strobe tuner and oscilloscope to R143 on VOICE CARD 1 (A VOICE).
3. Defeat VOICE CARDS 2 through 6 (B-F).
4A. Press "C", "4" and ENTER.
4B. The display will show "DEFEAT".
4C. Press "2" (for VOICE B) and ENTER.
4D. Repeat steps 4A through 4C for VOICES three through six. Substitute the appropriate voice number in Step 4C.
5. Attach DVM to wiper of VCF CUTOFF potentiometer.
6. Adjust control for 5.00 volts.
7. Depress and hold low C on keyboard.
8. Adjust EMPHASIS trim R153 for +10dBm (2.45Volts RMS, 6.9Volts peak-to-peak).
9. Adjust EMPHASIS BALANCE for a symmetrical sine wave.
10. Adjust FILTER RANGE trim R164 for E660Hz.
11. Depress and hold C3 on keyboard.
12. Adjust FILTER SCALE R167 for E2640Hz.
13. Depress and hold low C and repeat steps 10 through 12.
14. Repeat process for all other VOICE CARDS defeating the appropriate unused voices as in Step 4.

VII. VCA BALANCE ADJUSTMENT

1. Attach Hewlett Packard 400F A.C. voltmeter or equivalent to R143 on Voice Card 1.
2. Set up FRONT PANEL controls in Fig. 3.
3. Depress and release any note on the keyboard.
4. Adjust VCA trim R140 for minimum thump on A.C voltmeter.
5. Repeat for all other VOICE CARDS.

VIII. MAIN OSCILLATOR TUNING

NOTE:
NOTE: POWER SUPPLY and DMUX board adjustments must be verified with a 4-1/2 digit DVM before tuning is attempted. Set up FRONT PANEL controls as in Figure 3 and:

1. Attach Strobe tuner to the PULSE output of OSCILLATOR 1, VOICE CARD 1 at U3 Pin 1.
2. Defeat all VOICE CARDS except VOICE 1 (See Filter Tuning, Step 4, for procedure).
3. Depress low A.
4. Adjust R2 (OSC. 1 RANGE) for A220.
5. Depress A3, two octaves up.
6. Adjust R12 (OSC. 1 SCALE) for A880 (see "Overshooting" note above).
7. Repeat Steps 3 through 6 until a perfect 2 octave span is achieved.
8. Depress high A on the keyboard.
9. Adjust R10 (OSC. 1 HI END) for A3520.
10. Repeat Steps 3 through 9 until a perfect 5 octave span is achieved.
11. Repeat Steps 3 through 10 for OSCILLATOR 2 using junction of U7 Pin 1 for the Strobe tuner. Adjust R33 for A220, R44 for A880 and R42 for A3520.
12. Repeat Steps 3 through 10 for OSCILLATOR 3 using junction of U10 Pin 1 for the Strobe tuner. Adjust R75 for A220, R87 for A880 and R78 for A3520.
13. Repeat Steps 2 through 12 for VOICE CARDS 2 through 6 defeating appropriate unused voice cards in Step 2.
14. After all VOICE CARDS have been tuned, hit Low A and check the frequency of each OSCILLATOR on each VOICE CARD and adjust the appropriate range trim to A220, if necessary.
15. Enable all six voice cards by pressing "C", "4", ENTER, ENTER.

IX. MONOPHONIC SCALING ADJUSTMENT ON COMMON ANALOG BOARD

1. Attach Strobe tuner to OSCILLATOR 1 VOICE CARD 1 at U3 Pin 1.
2. Depress "MONO" button to turn it on.
3. Depress low A on keyboard.
4. Adjust OSCILLATOR 1 OFFSET R102 for A220.
5. Depress A3 on keyboard.
6. Adjust OSCILLATOR 1 SUM for A880.
7. Repeat Steps 3 through 6 until a perfect 2 octave span is achieved.
8. Repeat Steps 3 through 7 for OSCILLATOR 2 (U7 Pin 1) and OSCILLATOR 3 (U10 Pin 1).
9. Depress "MONO" button to turn it OFF.
10. Attach Strobe tuner to OSCILLATOR 1 VOICE CARD 1 at U3 Pin 1.
11. Depress A2 six times.
12. Depress 16' OCTAVE range on each OSCILLATOR.
13. Adjust OSCILLATOR 1 Offset for A110.
14. Depress 2' OCTAVE switch for OSCILLATOR 1.
15. Adjust OSCILLATOR 1 OCTAVE trim R104 for A880.
16. Repeat Steps 12 through 15 as necessary until a perfect 3 octave span is achieved.
17. Repeat Steps 12 through 16 for OSC2 (U7 Pin 1) and 3 (U10 Pin 1).
18. Press "AUTOTUNE" button and the display will show "6 TUNED" after about six seconds.

NOTE:
NOTE: If all VOICES are defeated accidentally, the unit may be RESET by shorting the central pin to an outside pin of the MANUAL RESET CONNECTOR P49 on the DIGITAL BOARD.

X. L.H.C. OCTAVE TRANSPOSE SCALE ADJUSTMENT

1. Attach Strobe tuner to OSC 1 Voice 1 (U3 Pin 1).
2. Set OCTAVE switch for OSC 1 to 4' range.
3. Depress Low A 220Hz.
4. Depress "-1" switch on LEFT HAND CONTROLLER.
5. Adjust the OCTAVE TRANSPOSE trim R32 for A110.
6. Depress "0" switch on LEFT HAND CONTROLLER.

XI. MODULATION OSCILLATOR RANGE AND SCALE

1. Attach a Time Interval Counter or Scope to the junction of R181, R182 and R183 on the COMMON ANALOG board.
2. Turn the MODULATION RATE Control fully counter-clockwise. Adjust R198 for a time period of 10.0 seconds.
3. Turn the MODULATION RATE Control fully clockwise. Adjust R200 for a time period of 10 milliseconds.

XII. PITCH WHEEL OFFSET ADJUSTMENT

1. Attach DVM probe to wiper of PITCH WHEEL.
2. Loosen PITCH WHEEL setscrew and mechanically adjust PITCH WHEEL pot shaft to achieve 0 volts +/-.1 volt on wiper if necessary.
3. Tighten setscrew on PITCH WHEEL.
4. Recheck voltage and readjust if necessary.
5. Attach Strobe tuner to OSC 1 VOICE 1 (U3 Pin 1).
6. Depress low A.

CALIBRATION DIAGRAM

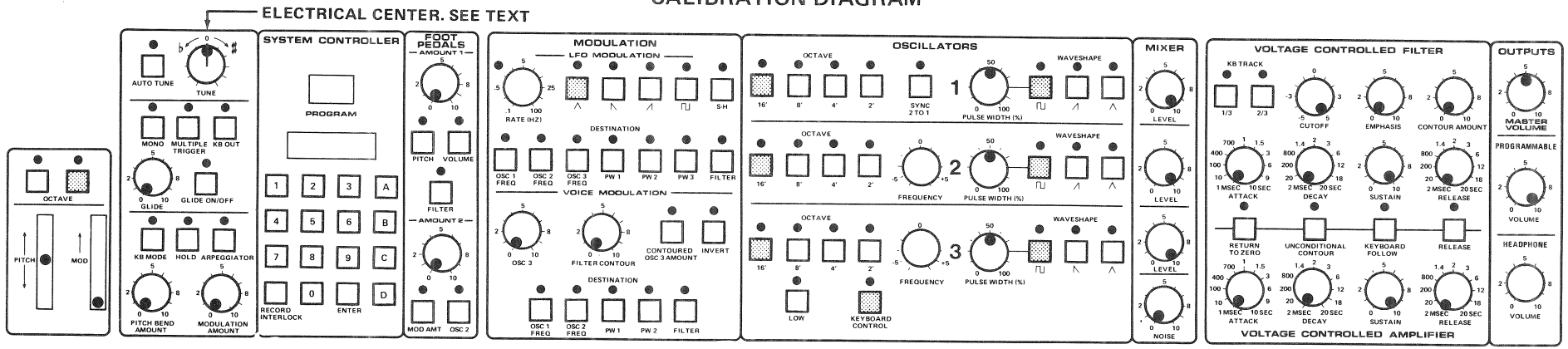


FIGURE 1 PRELIMINARY OSCILLATOR TUNING SET-UP

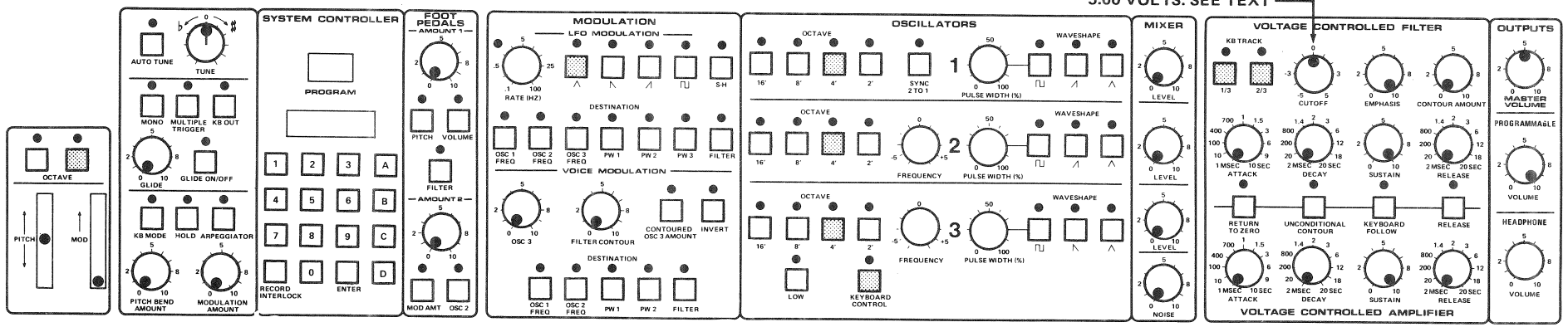


FIGURE 2 FILTER TUNING

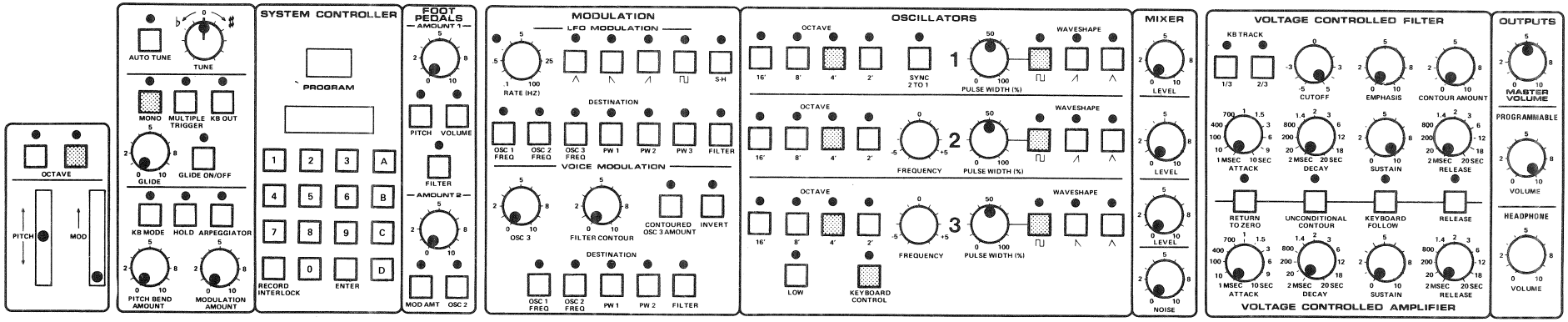


FIGURE 3 VCA BALANCE AND MAIN OSCILLATOR TUNING

MEMORYMOOG CALIBRATION PROCEDURE (CONT'D)

7. Turn PITCH BEND amount control full, clockwise.
8. Adjust PITCH Offset trim R67 on COMMON ANALOG board for no pitch shift.
9. Turn PITCH BEND AMOUNT fully counter-clockwise.

XIII. VOICE MODULATION OFFSET ADJUSTMENTS
1. Turn off all three wave shapes of OSCILLATOR 3 on FRONT PANEL.
2. Set the front panel VOICE MODULATION section controls as follows: OSCILLATOR 3 and FILTER ENVELOPE fully CCW, FREQUENCY 1 button ON and all other VOICE MODULATION buttons off.
3. Set front panel VOLTAGE CONTROLLED FILTER controls all fully CCW.
4. Attach STROBE tuner to OSCILLATOR 1 VOICE CARD 1 (U3 Pin 1).
5. Hit Low A and note the pitch.
6. Turn OSC. 3 control fully CW.
7. Adjust R106 (OSCILLATOR 3 OFFSET) on VOICE CARD for no pitch shift.
8. Turn OSC. 3 control fully CCW.
9. Turn FILTER ENVELOPE control fully CW.
10. Adjust CONTOURED MOD OFFSET trim on CONTOUR/GLIDE BOARD for no pitch shift (R128 VOICE 1, R161 VOICE 2, R190 VOICE 3, R219 VOICE 4, R248 VOICE 5, R277 VOICE 6).
11. Turn FILTER ENVELOPE control fully CCW.
12. Repeat Steps 5 through 11 above for VOICE CARDS 2 through 6 using Pin 1 of U3 or top of R143 on the associated VOICE CARD for the STROBE tuner and the associated offset trim of Step 10.

XIV. FOOT PEDAL INPUT ADJUSTMENT
1. Plug shorting jack into FOOT PEDAL 1.
2. Attach a STROBE tuner to OSCILLATOR 1 VOICE 1 (U3 Pin 1) and turn FOOT PEDAL AMOUNT controls 1 and 2 fully CCW.
3. Depress lowest A on keyboard.
4. Depress FOOT PEDAL PITCH button to turn it ON.
5. Adjust F.P.1 ZERO R8 on COMMON ANALOG board for no pitch shift.
6. Turn FOOT PEDAL AMOUNT 1 to maximum.
7. Adjust F.P.1 OFFSET R3 for no pitch shift.
8. Depress FOOT PEDAL PITCH button to turn it off.
9. Attach Strobe tuner to OSC 2 VOICE 1 (U7 Pin 1).
10. Depress FOOT PEDAL OSC 2 button to turn it on.
11. Adjust F.P.2 ZERO R17 for no pitch shift.
12. Turn FOOT PEDAL AMOUNT 2 clockwise.
13. Adjust F.P.2 offset R12 for no pitch shift.
14. Depress FOOT PEDAL OSC 2 button to turn it off.

SCHEMATIC UPDATES AND MODIFICATIONS

CONTOUR/GLIDE BOARD #3
Update schematic on U12B and U13A by reversing the +/- pins.

DMUX BOARD #5
Update pin 16 of 4051 ICs, U10 through U17 to +15 volts - current schematics erroneously indicate only +5 volts.

MODIFICATIONS:

VOICE CARD #1 A-F
Within the approximate serial number range 1169 through 1243, there are units with Curtis 3340 VCOs with date code 8226 which must be replaced. These date codes have a substrate problem which causes the oscillators to drift out of the AUTOTUNE capture range. Replace them with devices of any other date code. NOTE: Replace them systematically within each voice making sure to leave one old or new IC as a reference; then as replacement continues, reestablish a new reference oscillator.

DIGITAL BOARD #4
To eliminate digital cross-talk which causes a self-edit condition, shorten the heavy green ground wire soldered to the center of the digital board. From its current routing, reposition it straight to the back of the board eliminating 4 to 7 inches and resolder it in place (serial numbers 1000-1164).

LEFT SIDE CONTROL BOARD #7
To prevent damage to the negative battery lead and shorting of the control board to the battery case, remove the mounting screw and tinnerman nut from U10 and secure it with a pop rivet. Parallel the negative battery lead with a 1-inch strained wire. Bend the tab (above the spot-weld) perpendicular to the battery case and solder to it, then solder the other end to the printed circuit board trace. Note that the control board need only be loosened to accomplish the tinnerman removal and not totally disassembled. Use a magnet to remove the tinnerman if there is insufficient space (serial number 1545).

CONTOUR GLIDE BOARD #3
On the REAR PANEL JACK BOARD #9 schematic "insert", add a 470uf ceramic capacitor between pins 6 and 7 of U1B. This capacitor eliminates high frequency oscillation during tandem synthesizer operation - such as a connection to a Moog Source (below serial number 1440).

MEMORYMOOG PARTS LIST

SPECIAL NOTE
The following 4558 integrated circuits have been substituted with 1458 integrated circuits on some Memorymoog production runs. Field replacement should be effected with 4558 ICs as noted on schematics. VOICE CARD, BOARD #1 U2, U6, U9 & U19 COMMON ANALOG BOARD #2 U2, U9, U10, U15-U21, U23 & U26. CONTOUR/GLIDE BOARD #3 U1, U3, U5, U7, U11, U12, U13, U21, U22, U29, U37, U38, U45, U53, U54 & U61.

GENERAL PARTS LIST

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
345	997-045821-001	MEMORYMOOG, 100-127 VOLTS	200100 PRODUCT NO.
345X	997-045821-002	MEMORYMOOG, 200-254 VOLTS	200101 PRODUCT NO.
(1)	935-046074-001	CASSETTE, FACTORY PROGRAMS	SPECIAL ORDER
(2)	915-041298-002	KNOB, DUAL CONCENTRIC	FREQUENCY 2 & 3
(30)	997-041867-002	KNOB ASSEMBLY, POINTER	ALL OTHERS
(1)	932-045888-100	PACKING MATERIAL, COMPLETE	INCLUDES MANUAL
(1)	932-045890-002	FOAM, BOTTOM FILLER, PRECUT	39.8 X 20 X 1.5"
(2)	932-045890-001	FOAM, SIDE FILLER, RECTANGULAR	8.9 X 20 X 1.5"
(1)	932-045889-001	FOAM, TOP FILLER, PRECUT	39.9 X 20 X 7.0"
(1)	932-045888-001	CARTON, SHIPPING	44.5 X 21 X 9.5"
(1)	932-040643-001	BAG, POLY PACKING, TUBULAR	77.0 X 23 X .01"
(1)	997-045924-001	OWNER/SERVICE MANUAL ASSEMBLY	3 RING BINDER
(1)	997-044666-001	PROM UPDATE KIT (SOFTWARE)	LATEST VERSION
(1)	997-044667-001	MEMORYMOOG ROAD KIT	SELECTED PARTS

CABINET, CHASSIS & KEYBOARD

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(1)	967-045822-940	HOUSING, CABINET COMPLETE	INCLUDES OVERLAYS
(1)	967-045825-001	BASE, ALUMINUM	BOTTOM PANEL
(3)	967-045831-001	BRACKET 3/4 X 13/16 X 5/8	VINYL CLAD, END CAP
(9)	967-045831-002	BRACKET 1 X 1 X 5/8	VINYL CLAD, END CAP
(2)	967-045831-003	BRACKET 1 X 5/16 X 5/8	VINYL CLAD, END CAP
(1)	962-045832-001	COVER PLATE ALUMINUM	INTERFACE PANEL
(1)	967-045883-001	DOUBLER PLATE, BASE	TRANSFORMER SUPPORT
(1)	962-045827-001	END CAP, LEFT HAND ALUMINUM	FRONT PANEL
(1)	962-045827-002	END CAP, RIGHT HAND ALUMINUM	FRONT PANEL
(1)	967-045823-001	FRONT PANEL, ALUMINUM	LHC & KEYBOARD
(1)	962-045828-001	LOGO, MEMORYMOOG ALUMINUM	FRONT PANEL
(1)	967-045822-001	HOUSING, CABINET ALUMINUM	FRONT PANEL
(1)	913-045588-002	OVERLAY, CONTROLS CENTER	OSCILLATORS
(1)	913-045588-001	OVERLAY, CONTROLS LEFT SIDE	SYSTEM CONTROLLER
(1)	913-045588-003	OVERLAY, CONTROLS RIGHT SIDE	VCF & VCA
(1)	913-045588-004	OVERLAY, CONTROLLER, LEFT HAND	PITCH & MODULATION
(1)	972-045826-001	SIDE PANEL, LEFT SIDE WOOD	5/8" WALNUT

CABINET, CHASSIS & KEYBOARD (CONT'D)

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(1)	972-045826-002	SIDE PANEL, RIGHT SIDE WOOD	5/8" WALNUT
(1)	967-045830-005	STIFFENER, BASE ALUMINUM	L-BRACKET
(1)	972-045829-004	TRIM, BLOCK HOUSING WOOD	5/8" WALNUT
(1)	972-045829-001	TRIM, CENTER BRACE WOOD	1" UNFINISHED MAPLE
(1)	972-045829-002	TRIM, FRONT KEYBOARD WOOD	3/8" MAPLE
(1)	972-045829-003	TRIM, RIGHT SIDE WOOD	3/8" MAPLE
(1)	972-045829-005	TRIM, LEFT SIDE WOOD	3/8" MAPLE
(1)	979-045424-001	KEYBOARD, C TO C	61 NOTE
(5)	964-044686-001	KEY, WHITE C	LABELED C
(5)	964-044686-002	KEY, WHITE D	LABELED D
(5)	964-044686-003	KEY, WHITE E	LABELED E
(5)	964-044686-004	KEY, WHITE F	LABELED F
(5)	964-044686-005	KEY, WHITE G	LABELED G
(5)	964-044686-006	KEY, WHITE A	LABELED A
(5)	964-044686-007	KEY, WHITE B	LABELED B
(1)	964-044686-008	KEY, WHITE HIGH C	LABELED CC
(25)	964-044686-009	KEY, BLACK	K70BK5
(61)	975-044687-001	SPRING, RETURN	KEY

HARDWARE

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE (ALPHABETICALLY)
(17)	916-045163-001	BUMPER, RUBBER	STEM TYPE
(4)	916-042584-001	FOOT, BLACK RUBBER	7/8 DIA X 3/8"
(1)	911-040189-002	LUG, CRIMP	#8
(18)	902-040504-007	NUT, HEX	3/8-32
(4)	802-055449-000	NUT, HEX KEPS	8-32
(2)	801-045332-000	NUT, HEX KEPS BLACK	6-32
(41)	802-045322-000	NUT, HEX KEPS ZINC	6-32
(1)	801-055446-000	NUT, HEX ZINC	8-32
(3)	902-040500-001	NUT, TINNERMAN "U" TYPE	#6A
(1)	913-040328-001	OVERLAY, MOOG LOGO	7 X 2.4"
(10)	903-045216-001	SCREW, .165/.175	#8 X 5/8"
(6)	903-044310-001	SCREW, MACHINE	5M X 12 MM
(9)	806-045039-006	SCREW, MACHINE BLACK	6-32 X 3/8"
(2)	806-023039-006	SCREW, MACHINE BLACK	4-40 X .375"
(4)	806-045039-010	SCREW, MACHINE BLACK	6-32 X 5/8"
(8)	806-055039-005	SCREW, MACHINE CADMIUM	8-32 X 5/16"
(4)	806-055032-010	SCREW, MACHINE CADMIUM	8-32 X 5/8"
(2)	806-065232-006	SCREW, MACHINE FLAT HD	10-32 X 3/8"
(12)	816-050039-006	SCREW, SELF-TAPPING BLACK	8B X 3/8"
(3)	811-040039-008	SCREW, SELF-TAPPING BLACK	6A X 1/2" BLK
(11)	811-050039-008	SCREW, SELF-TAPPING BLACK	8A X 1/2"
(10)	811-050039-016	SCREW, SELF-TAPPING BLACK	8A X 1"
(8)	811-050039-020	SCREW, SELF-TAPPING BLACK	8A X 1-1/4"
(7)	811-040331-004	SCREW, SELF-TAPPING NICKEL	6A X 1/4"
(6)	811-040311-004	SCREW, SELF-TAPPING NICKEL	6A X 1/4"
(30)	812-045039-004	SCREW, SEMS PAN HEAD BLACK	6-32 X 1/4"
(4)	973-041409-018	STANDOFF, NYLON SPACER	#6 X 1/4"
(2)	904-040507-020	SPACER, BLACK OXIDE	#4
(26)	973-040508-063	STANDOFF, HEX ZINC	6-32 X .625"
(4)	973-040508-064	STANDOFF, HEX ZINC	6-32 X 3/4"
(4)	973-040508-066	STANDOFF, HEX ZINC	6-32 X 1 1/8"
(4)	973-040789-003	STANDOFF, HINGED CADMIUM	6-32 X 3/4"
(4)	973-040789-004	STANDOFF, HINGED CADMIUM	6-32 X 1"
(20)	973-040517-001	STANDOFF, MALE-FEMALE, HEX	6-32 X 1/4"
(6)	973-045326-001	SUPPORT, PC BOARD SCR MOUNT	1/4"
(2)	904-041309-007	WASHER, FLAT	#8
(16)	904-042026-001	WASHER, FLAT NICKEL	3/8 CONICAL
(4)	904-041391-010	WASHER, FLAT ZINC	10S X 3/4" OD

HARDWARE (CONT'D)

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(6)	904-041406-010	WASHER, INSULATED FIBRE	6 X 5/16" OD
(6)	904-041546-003	WASHER, INSULATED FIBRE	3/8 X 5/8"
(1)	904-040495-015	WASHER, LOCK INTERNAL TOOTH	#4
(10)	904-040495-016	WASHER, LOCK INTERNAL TOOTH	#6
(12)	904-040495-021	WASHER, LOCK NICKEL	3/8
(20)	904-041395-008	WASHER, LOCK SPRING CADMIUM	#8
(6)	904-041395-009	WASHER, LOCK SPRING ZINC	#8

CONNECTORS & HARDWARE

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE (ALPHABETICALLY)
(1)	906-040392-001	CONN, 045 HOUSING SQUARE	15 PIN .156" CNTRS.
(1)	910-045921-016	CONN, HOUSING METRIC	16 PIN 2.5MM C/L
(26)	910-040308-001	CONN, CIS CRIMP SOCKET	TERMINAL
(3)	910-040310-001	CONN, CIS KEYING PLUG	BLACK PLUG
S92	906-040298-005	CONN, CIS HOUSING SOCKET	5 PIN .1 CT
S91	906-040298-008	CONN, CIS HOUSING SOCKET	8 PIN .1 CT
S63	910-045895-008	CONN, CIS HOUSING SOCKET	8 PIN .1 CT
S64	910-045895-008	CONN, CIS HOUSING SOCKET	8 PIN .1 CT
S514	910-045895-002	CONN, MTA HOUSING	2 PIN GROUND
S514	910-045895-002	CONN, MTA HOUSING	2 PIN +15 VOLT
S514	910-045895-002	CONN, MTA HOUSING	2 PIN -15 VOLT
S13ACEF	910-045895-203	CONN, MTA HOUSING RED	22AWG 3 PIN
S13B	910-045895-003	CONN, MTA HOUSING RED	22AWG 3 PIN
S13D	910-045895-003	CONN, MTA HOUSING RED	22AWG 3 PIN
S14B	910-045895-004	CONN, MTA HOUSING RED	22AWG 4 PIN
S14ACDEF	910-045895-204	CONN, MTA HOUSING RED	22AWG 4 PIN
S15A-F	910-045895-002	CONN, MTA HOUSING RED	22AWG 2 PIN
S16A-F	910-045895-004	CONN, MTA HOUSING RED	22AWG 4 PIN
S17A-F	910-045895-004	CONN, MTA HOUSING RED	22AWG 4 PIN
S24	910-045895-006	CONN, MTA HOUSING RED	22AWG 6 PIN
S25	910-045895-007	CONN, MTA HOUSING RED	22AWG 7 PIN
S26	920-045895-006	CONN, MTA HOUSING RED	22AWG 6 PIN
S27	920-045895-004	CONN, MTA HOUSING RED	22AWG 4 PIN
S28	910-045895-005	CONN, MTA HOUSING RED	22AWG 5 PIN
S29	910-045895-007	CONN, MTA HOUSING RED	22AWG 7 PIN
S30	910-045895-006	CONN, MTA HOUSING RED	22AWG 6 PIN
S31	910-045895-008	CONN, MTA HOUSING RED	22AWG 8 PIN
S34	910-045895-005	CONN, MTA HOUSING RED	22AWG 5 PIN
S35	910-045895-006	CONN, MTA HOUSING RED	22AWG 6 PIN
S36A-F	910-045895-003	CONN, MTA HOUSING RED	22AWG 3 PIN
S42	910-045895-005	CONN, MTA HOUSING RED	22AWG 5 PIN
S44	910-045895-006	CONN, MTA HOUSING RED	22AWG 6 PIN
S47	910-045895-006	CONN, MTA HOUSING RED	22AWG 6 PIN
S48A-B	910-045895-008	CONN, MTA HOUSING RED	22AWG 8 PIN
S77	910-045895-008	CONN, MTA HOUSING RED	22AWG 8 PIN
S78	910-045895-008	CONN, MTA HOUSING RED	22AWG 8 PIN
S511	910-045895-006	CONN, MTA HOUSING RED	22AWG 6 PIN
S512	910-045895-004	CONN, MTA HOUSING RED	22AWG 4 PIN
S513	910-045895-004	CONN, MTA HOUSING RED	22AWG 4 PIN
S515A-F	910-045895-003	CONN, MTA HOUSING RED	22AWG 3 PIN
S516	910-045895-010	CONN, MTA HOUSING RED	22AWG 10 PIN
S517	910-045895-004	CONN, MTA HOUSING RED	22AWG 4 PIN
S518	910-045895-007	CONN, MTA HOUSING RED	22AWG 7 PIN
S519	910-045895-008	CONN, MTA HOUSING RED	22AWG 8 PIN
S520	910-045895-006	CONN, MTA HOUSING RED	22AWG 6 PIN
(14)	910-040393-002	CONN, 045 SOCKET CRIMP	SQUARE
(3)	910-041316-001	PIN, UNIVERSAL CONTACT	MATE-N-LOCK
(16)	910-045922-001	TERMINAL, CRIMP MOLEX	KEYBOARD
P11-P53	994-045350-101	RIBBON CABLE ASSY 16 PIN	DIP 54.5" 7 PLUGS
P12-P54	994-045350-102	RIBBON CABLE ASSY 16 PIN	DIP 59.0" 7 PLUGS

CONNECTORS & HARDWARE (CONT'D)

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
P21-P55	994-045350-008	RIBBON CABLE ASSY 16 PIN	DIP 13.0" 2 PLUGS
P22-P56	994-045350-006	RIBBON CABLE ASSY 16 PIN	DIP 11.5" 2 PLUGS
P23-P57	994-045350-013	RIBBON CABLE ASSY 16 PIN	DIP 7.5" 2 PLUGS
P32-P58	994-045350-009	RIBBON CABLE ASSY 16 PIN	DIP 16.5" 2 PLUGS
P33-P59	994-045350-007	RIBBON CABLE ASSY 16 PIN	DIP 12.5" 2 PLUGS
P43-P52	994-045350-010	RIBBON CABLE ASSY 16 PIN	DIP 18.5" 2 PLUGS
P44-P73	994-045350-012	RIBBON CABLE ASSY 16 PIN	DIP 29.5" 2 PLUGS
P45-P51	994-045350-005	RIBBON CABLE ASSY 16 PIN	DIP 11.0" 2 PLUGS
P46-P71	994-045350-011	RIBBON CABLE ASSY 16 PIN	DIP 22.0" 2 PLUGS
P61-P75	994-045350-005	RIBBON CABLE ASSY 16 PIN	DIP 11.0" 2 PLUGS
P62-P72	994-045350-011	RIBBON CABLE ASSY 16 PIN	DIP 22.0" 2 PLUGS

HARNESSING ASSEMBLIES

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
S47	994-045894-972*	HARNESS, CASSETTE INTERFACE	J14, J15 & J16
S76	994-045894-975	HARNESS, DISPLAY BOARD POWER	TO BOARD #8
S74	994-045894-946	HARNESS, DISPLAY BOARD DATA	TO BOARD #8
S24	994-045894-963*	HARNESS, LEFT HAND CONTROLLER	TO BOARD #10
S78	994-045894-977	HARNESS, POWER, LSC TO RSC	S63
S26	994-045894-965*	HARNESS, POWER, COMMON ANALOG	S518
S40	994-045894-970*	HARNESS, POWER, DIGITAL BOARD	S520
S42	994-045894-971*	HARNESS, DMUX/DIGITAL (CLOCK)	S517
S27-S92	994-045894-966*	HARNESS, TO BACK PANEL JACKS	S1, S41, J11 & J12
S29	994-045894-960	HARNESS, SHIELDED, VOICE AUDIO	S15 A THRU F
S516-S25	994-045894-964*	HARNESS, PWR/DMUX TO LSC/RSC	S77-S64
S36A-F	994-045894-961	HARNESS, KB CV & ADSR TO BD #1	S16A-F, S35A-F
S511A-F	994-045894-962	HARNESS, AUTOTUNE AND OSC3	S17A-F, S515A-F
S519	994-045894-968	HARNESS, PWR TO C/G BOARD	S31
S512	994-045894-978	HARNESS, 7.5V TO V.C.	S14A-F
S514	994-045894-979	HARNESS, 15V TO V.C.	S13A-F
S48A&B	994-045894-973	HARNESS, KB TO DIGITAL BOARD	S121
S28-BD5	994-045894-967	HARNESS, DMUX TO C/A	PADS 1-5
S131	994-045894-974	HARNESS, POWER TO DMUX BOARD	P510 PADS 1-15
S34-S91	994-045894-969	HARNESS, PWR/ADSR	S513-S91
S513-S91	994-045894-999	HARNESS, MAIN - INCLUDES *	*SEE ABOVE

POWER CONNECTIONS

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(1)	910-042913-001	RECEPTACLE, POWER	CEE-22
(1)	913-044099-001	LABEL, SAFETY GROUND	EXPORT
(1)	913-045130-006	LABEL, VOLTAGE	120 VOLT
(1)	913-045130-005	LABEL, VOLTAGE	240 VOLT EXPORT
(1)	954-045882-001	TRANSFORMER, POWER	120 OR 240V
(1)	957-041794-001	CORD, POWER, 3-CONDUCTOR	18 AWG, 5' DOMESTIC
(1)	957-043400-001	CORD, EUROPEAN, 3-CONDUCTOR	TYPE B
(1)	960-042800-001	SWITCH, ROCKER, DPST	250V/8A ON/OFF
	997-045885-001	FUSE PLATE ASSEMBLY	120 VOLT DOMESTIC
(1)	806-023039-006	SCREW, PAN HEAD BLACK	4-40 X 3/8"
(1)	906-041331-006	FUSEHOLDER, SINGLE .250 TAB	DOMESTIC TYPE
(1)	939-041620-006	FUSE, SLO-BLO 3AG 250V	1.25 AMP
(1)	962-045931-001	PLATE, ALUMINUM, DOMESTIC	FUSE PLATE, 120V

POWER CONNECTIONS (CONT'D)

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
	997-045885-002	FUSE PLATE ASSEMBLY	240 VOLT EXPORT
(5)	806-023029-006	SCREW, PAN HEAD BLACK	4-40 X 3/8"
(1)	906-042911-003	FUSEHOLDER, CLIP TYPE	5 X 20MM
(1)	939-044094-013	FUSE, TIME LAG, EUROPEAN	5 X 20MM 800MA
(1)	939-044094-011	FUSE, TIME LAG, EUROPEAN	5 X 20MM 315MA
(3)	939-044094-002	FUSE, TIME LAG, EUROPEAN	5 X 20MM 3.15A
(1)	962-045931-001	PLATE, ALUMINUM, EXPORT	FUSE PLATE, 240V
(1)	969-045948-001	SHIELD, FISH PAPER	FORMED

935-045940-100 FAN ASSEMBLY

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(4)	802-065542-000	NUT, HEX KEPS CADMIUM	10-32
(4)	806-065032-010	SCREW, MACHINE CADMIUM	10-32 X 5/8"
(4)	916-045961-001	MOUNT, VIBRATION RUBBER	BLACK
(1)	935-045940-001	FAN MOTOR, 115VAC	50/60 HERTZ
(1)	935-045940-002	FAN BLADE	
(2)	967-045941-901	BRACKET, FAN PEM INSERTED	FAN MOUNTING

997-041597-002 LEFT HAND CONTROLLER

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(1)	925-040930-003	POT, ROTARY LINEAR	10K MODULATION
(1)	925-040930-003	POT, ROTARY LINEAR	10K PITCH BEND
(1)	962-041179-001	DETENT, TEFLON	PITCH WHEEL
(1)	961-041178-001	DETENT, SPRING	PITCH WHEEL
(2)	967-041185-003	BRACKET, POT L.H. CONTROL	MOD & PITCH BEND
(2)	997-041597-002	WHEEL, LEFT HAND GRAY	MOD & PITCH BEND

996-045643-001 VOICE CARD BOARD #1 A-F

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(2)	908-045886-002	INSULATOR, FISH PAPER 8 X 8	VOICE CARDS
CR1	919-041075-001	DIODE, SIGNAL, SILICON	1N4148
C1	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C2	947-045008-102	CAPACITOR, CERAMIC TUBULAR	.001 UFD
C3	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C4	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C5	946-041978-102	CAPACITOR, POLYESTER BOX	.001 UFD
C6	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C7	945-044465-002	CAPACITOR, ALUMINUM ELECT.	1 UFD/50V
C8	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C9	947-045008-102	CAPACITOR, CERAMIC TUBULAR	.001 UFD
C10	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C11	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C12	946-041978-102	CAPACITOR, POLYESTER BOX	.001 UFD
C13	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD

996-045643-001 VOICE CARD BOARD #1 A-F (CONT'D)

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
C14	947-045008-221	CAPACITOR, CERAMIC TUBULAR	220 PFD
C15	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C16	945-044465-002	CAPACITOR, ALUMINUM ELECT.	1 UFD/50V
C17	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C18	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C19	947-045008-102	CAPACITOR, CERAMIC TUBULAR	.001 UFD
C20	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C21	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C22	946-041978-102	CAPACITOR, POLYESTER BOX	.001 UFD
C23	946-041978-333	CAPACITOR, POLYESTER BOX	.033 UFD
C24	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C25	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C26	946-040190-224	CAPACITOR, POLYESTER	.22 UF
C27	945-044465-006	CAPACITOR, ALUMINUM ELECT.	220 UFD/6.3V
C28-C31	946-041978-273	CAPACITOR, POLYESTER BOX	.027 UFD
C32-C35	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C36	947-045008-101	CAPACITOR, CERAMIC TUBULAR	100 PFD
C37	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C38	947-045011-100	CAPACITOR, CERAMIC TUBULAR	10 PFD
R2	925-040378-007	POT, TRIM CERMET 20 TURN	100K OSC 1 RANGE
R10	925-040275-004	POT, TRIM CARBON	10K OSC 1 HI
R12	925-040378-001	POT, TRIM CERMET 20 TURN	10K OSC 1 SCALE
R33	925-040378-007	POT, TRIM CERMET 20 TURN	100K OSC 2 RANGE
R42	925-040275-004	POT, TRIM CARBON	10K OSC 2 HI
R43	925-040378-001	POT, TRIM CERMET 20 TURN	10K OSC 2 SCALE
R75	925-040378-007	POT, TRIM CERMET 20 TURN	100K OSC 3 RANGE
R78	925-040275-004	POT, TRIM CARBON	10K OSC 3 HI
R87	925-040378-001	POT, TRIM CERMET 20 TURN	10K OSC 3 SCALE
R106	925-040275-004	POT, TRIM CARBON	10K OSC 3 OFFSET
R140	925-040275-004	POT, TRIM CARBON	10K VCA OFFSET
R151	925-040275-004	POT, TRIM CARBON	10K EMPHASIS BAL
R153	925-040275-004	POT, TRIM CARBON	10K EMPHASIS AMNT
R164	925-040275-004	POT, TRIM CARBON	10K VCF RANGE
R167	925-042389-002	POT, TRIM CERMET	10K VCF SCALE
N1	949-045875-001	NETWORK, RESISTOR DIP .1%	100K
N2	949-040207-001	NETWORK, RESISTOR SIP	VCF LADDER
(10)	906-045188-008	SOCKET, IC DIP .3" CTRS.	8 PIN
(9)	906-045188-014	SOCKET, IC DIP .3" CTRS.	14 PIN
(5)	906-045188-016	SOCKET, IC DIP .3" CTRS.	16 PIN
P13	910-046058-003	HEADER, CIS .1" CTRS. LOCKING	3 PIN
P14	910-046058-004	HEADER, CIS .1" CTRS. LOCKING	4 PIN
P15	910-046058-002	HEADER, CIS .1" CTRS. LOCKING	2 PIN
P16	910-046058-004	HEADER, CIS .1" CTRS. LOCKING	4 PIN
P17	910-046058-004	HEADER, CIS .1" CTRS. LOCKING	4 PIN
Q1	991-041052-002	TRANSISTOR, PNP SMALL SIG.	2N3906
Q2	991-041051-002	TRANSISTOR, NPN SMALL SIG.	2N3904
Q3	991-041051-002	TRANSISTOR, NPN SMALL SIG.	2N3904
Q4	991-045871-001	TRANSISTOR, NPN DUAL PAIR	IT122
Q5-Q10	991-042017-100	TRANSISTOR, NPN SMALL SIG.	2N3392
Q11	991-045871-001	TRANSISTOR, NPN DUAL PAIR	IT122
Q12	991-041052-002	TRANSISTOR, PNP SMALL SIG.	2N3906
Q13	991-041052-002	TRANSISTOR, PNP SMALL SIG.	2N3906
Q14	991-045871-001	TRANSISTOR, NPN DUAL PAIR	IT122
U1	991-045869-001	IC, VC OSCILLATOR	CEM3340
U2	991-041146-001	IC, DUAL OP AMP	4558
U3	991-041087-001	IC, CMOS QUAD SWITCH	4016B
U4	991-045870-001	IC, DUAL VC AMPLIFIER	CEM3360
U5	991-045869-001	IC, VC OSCILLATOR	CEM3340
U6	991-041146-001	IC, DUAL OP AMP	4558
U7	991-041087-001	IC, CMOS QUAD SWITCH	4016B
U8	991-045869-001	IC, VC OSCILLATOR	CEM3340
U9	991-041146-001	IC, DUAL OP AMP	4558
U10	991-041087-001	IC, CMOS QUAD SWITCH	4016B

996-045643-001 VOICE CARD BOARD #1 A-F (CONT'D)

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
U11	991-042793-001	IC, BIFET OP AMP	LF351 (TLO71)
U12	991-042908-001	IC, DUAL BIFET OP AMP	LF353 (TLO72)
U13	991-045870-001	IC, DUAL VC AMPLIFIER	CEM3360
U14	991-041146-001	IC, DUAL OP AMP	4558
U15-U18	991-041087-001	IC, CMOS QUAD SWITCH	4016B
U19	991-041146-001	IC, DUAL OP AMP	4558
U20	991-042908-001	IC, DUAL BIFET OP AMP	LF353 (TLO72)
U21	991-041089-004	IC, OPER. TRANSCOND. AMP	3080A
U22	991-041089-004	IC, OPER. TRANSCOND. AMP	3080A
U23	991-044316-101	IC, VOLTAGE REGULATOR -5V	79L05

996-045646-001 COMMON ANALOG BOARD #2

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(1)	908-045886-001	INSULATOR, FISH PAPER 6.4 X 16.1	DIGITAL BOARD
CR1	919-044466-001	DIODE, LOW LEAKAGE	FDH333
CR2	919-044466-001	DIODE, LOW LEAKAGE	FDH333
CR3	919-041075-001	DIODE, SMALL SIGNAL	1N4148
CR4	919-041075-001	DIODE, SMALL SIGNAL	1N4148
CR5	919-041349-004	DIODE, ZENER 8.2V/500 MW	1N5237A
CR6	919-041075-001	DIODE, SMALL SIGNAL	1N4148
CR7	919-041075-001	DIODE, SMALL SIGNAL	1N4148
CR8	919-041075-001	DIODE, SMALL SIGNAL	1N4148
CR9	919-041075-001	DIODE, SMALL SIGNAL	1N4148
CR10	919-041349-004	DIODE, ZENER 8.2V/500 MW	1N5237A
CR11	919-041349-004	DIODE, ZENER 8.2V/500 MW	1N5237A
CR12	919-041075-001	DIODE, SMALL SIGNAL	1N4148
CR13	919-041075-001	DIODE, SMALL SIGNAL	1N4148
Q1	991-041052-002	TRANSISTOR, PNP SMALL SIG.	2N3906
Q2	991-041051-002	TRANSISTOR, NPN SMALL SIG.	2N3904
Q3	991-041052-002	TRANSISTOR, PNP SMALL SIG.	2N3906
Q4-Q6	991-041051-002	TRANSISTOR, NPN SMALL SIG.	2N3904
Q7	991-041055-001	TRANSISTOR, FET N-CHANNEL	E112
Q8	991-041051-002	TRANSISTOR, NPN SMALL SIG.	2N3904
Q9	991-041052-002	TRANSISTOR, PNP SMALL SIG.	2N3906
Q10	991-041051-002	TRANSISTOR, NPN SMALL SIG.	2N3904
U1	991-045870-001	IC, DUAL VOLTAGE CONT AMP	CEM3360
U2	991-041146-001	IC, DUAL OP AMP	4558
U3	991-041087-001	IC, CMOS QUAD SWITCH	4016B
U4	991-041087-001	IC, CMOS QUAD SWITCH	4016B
U5	991-045870-001	IC, DUAL VOLTAGE CONT AMP	CEM3360
U6	991-045870-001	IC, DUAL VOLTAGE CONT AMP	CEM3360
U7	991-042908-001	IC, DUAL JFET OP AMP	LF353 (TLO72)
U8	991-045137-001	IC, AUDIO OP AMP	LM386
U9	991-041146-001	IC, DUAL OP AMP	4558
U10	991-041146-001	IC, DUAL OP AMP	4558
U11	991-045870-001	IC, DUAL VOLTAGE CONT AMP	CEM3360
U12	991-041101-001	IC, OP AMP	741
U13	991-041087-001	IC, CMOS QUAD SWITCH	4016B
U14	991-041087-001	IC, CMOS QUAD SWITCH	4016B
U15	991-041146-001	IC, DUAL OP AMP	4558
U16	991-041146-001	IC, DUAL OP AMP	4558
U17	991-041146-001	IC, DUAL OP AMP	4558
U18	991-041146-001	IC, DUAL OP AMP	4558
U19	991-041146-001	IC, DUAL OP AMP	4558
U20	991-041146-001	IC, DUAL OP AMP	4558
U21	991-041146-001	IC, DUAL OP AMP	4558
U22	991-045869-001	IC, VOLTAGE CONTROLLED OSC	CEM3340
U23	991-041146-001	IC, DUAL OP AMP	4558

996-045646-001 COMMON ANALOG BOARD #2 (CONT'D)

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
U24	991-041087-001	IC, CMOS QUAD SWITCH	4016B
U25	991-042016-001	IC, DIGITAL NOISE SOURCE	5837
U26	991-041146-001	IC, DUAL OP AMP	4558
U27	991-042908-001	IC, DUAL JFET OP AMP	LF353 (TL072)
U28	991-041087-001	IC, CMOS QUAD SWITCH	4016B
C1	947-045008-472	CAPACITOR, CERAMIC TUBULAR	4.7 NFD
C2	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C3	947-045008-472	CAPACITOR, CERAMIC TUBULAR	4.7 NFD
C4	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C5	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C6	945-044465-002	CAPACITOR, ALUMINUM ELECT.	1 UFD/50V
C7	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C8	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C9	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C10	945-044465-019	CAPACITOR, ALUMINUM ELECT.	220 UFD/16V
C11	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C12	947-045008-472	CAPACITOR, CERAMIC TUBULAR	4.7 NFD
C13	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C14	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C15	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C16	947-045001-221	CAPACITOR, CERAMIC TUBULAR	220 PFD
C17	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C18	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C19	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C20	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C21	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C22	945-040209-014	CAPACITOR, ALUMINUM ELECT.	2.2 UFD/25V
C23	946-041978-124	CAPACITOR, POLYESTER BOX	.12 UFD
C24	946-041978-333	CAPACITOR, POLYESTER BOX	.033 UFD
C25	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C26	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C27	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C28	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C29	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C30	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C31	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C32	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C33	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C34	947-045008-102	CAPACITOR, CERAMIC TUBULAR	.001 UFD
C35	947-045008-102	CAPACITOR, CERAMIC TUBULAR	.001 UFD
C36	947-045008-102	CAPACITOR, CERAMIC TUBULAR	.001 UFD
C37	947-045008-472	CAPACITOR, CERAMIC TUBULAR	4.7 NFD
(17)	906-045188-008	SOCKET, IC DIP .3" CNTRS.	8 PIN
(10)	906-045188-014	SOCKET, IC DIP .3" CNTRS.	14 PIN
(4)	906-045188-016	SOCKET, IC DIP .3" CNTRS.	16 PIN
P24	910-040299-006	HEADER, CIS .1" CNTRS.	6 PIN
P25	910-040299-007	HEADER, CIS .1" CNTRS.	7 PIN
P26	910-040299-006	HEADER, CIS .1" CNTRS.	6 PIN
P27	910-040299-010	HEADER, CIS .1" CNTRS.	10 PIN
P28	910-040299-005	HEADER, CIS .1" CNTRS.	5 PIN
P29	910-040299-007	HEADER, CIS .1" CNTRS.	7 PIN
R3	925-040275-004	POT, TRIM CARBON	10K FP1 OFFSET
R8	925-040275-004	POT, TRIM CARBON	10K FP1 ZERO
R12	925-040275-004	POT, TRIM CARBON	10K FP2 OFFSET
R17	925-040275-004	POT, TRIM CARBON	10K FP2 ZERO
R30	925-042389-002	POT, TRIM CERMET	10K OCT TRANS
R37	925-040275-003	POT, TRIM CARBON	50K VOICE B LEVEL
R39	925-040275-003	POT, TRIM CARBON	50K VOICE C LEVEL
R41	925-040275-003	POT, TRIM CARBON	50K VOICE D LEVEL
R43	925-040275-003	POT, TRIM CARBON	50K VOICE E LEVEL
R45	925-040275-003	POT, TRIM CARBON	50K VOICE F LEVEL
R67	925-042389-002	POT, TRIM CERMET	10K PITCH OFFSET
R84	925-040275-004	POT, TRIM CARBON	10K MOD OFFSET
R102	925-042389-002	POT, TRIM CERMET	10K OSC 1 OFFSET

996-045646-001 COMMON ANALOG BOARD #2 (CONT'D)

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
R104	925-042389-012	POT, TRIM CERMET	50K OSC 1 OCTAVE
R107	925-042389-002	POT, TRIM CERMET	10K OSC 1 SUM
R111	925-042389-002	POT, TRIM CERMET	10K OSC 2 OFFSET
R114	925-042389-012	POT, TRIM CERMET	50K OSC 2 OCTAVE
R120	925-042389-002	POT, TRIM CERMET	10K OSC 2 SUM
R123	925-042389-002	POT, TRIM CERMET	10K OSC 3 OFFSET
R125	925-042389-012	POT, TRIM CERMET	50K OSC 3 OCTAVE
R136	925-042389-002	POT, TRIM CERMET	10K OSC 3 SUM
R198	925-040275-004	POT, TRIM CARBON	10K MOD RATE SCL
T1	955-045879-001	TRANSFORMER, AUDIO DRIVER	600 OHM BAL. LINE

996-045649-001 CONTOUR/GLIDE BOARD #3

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(28)	906-045188-008	SOCKET, IC DIP .3" CNTRS.	8 PIN
(21)	906-045188-014	SOCKET, IC DIP .3" CNTRS.	14 PIN
(14)	906-045188-016	SOCKET, IC DIP .3" CNTRS.	16 PIN
	910-046058-002	HEADER, CIS .1" CNTRS. LOCKING	2 PIN
P36	910-046058-003	HEADER, CIS .1" CNTRS. LOCKING	3 PIN
P34	910-046058-005	HEADER, CIS .1" CNTRS. LOCKING	5 PIN
P35	910-046058-006	HEADER, CIS .1" CNTRS. LOCKING	6 PIN
	910-046058-007	HEADER, CIS .1" CNTRS. LOCKING	7 PIN
P31	910-046058-008	HEADER, CIS .1" CNTRS. LOCKING	8 PIN
U1	991-041146-001	IC, DUAL OP AMP	4558
U2	991-045870-002	IC, DUAL VC AMPLIFIER	CEM3360
U3	991-041146-001	IC, DUAL OP AMP	4558
U4	991-045870-002	IC, DUAL VC AMPLIFIER	CEM3360
U5	991-041146-001	IC, DUAL OP AMP	4558
U6	991-045870-002	IC, DUAL VC AMPLIFIER	CEM3360
U7	991-041146-001	IC, DUAL OP AMP	4558
U8	991-045870-002	IC, DUAL VC AMPLIFIER	CEM3360
U9	991-041087-001	IC, CMOS QUAD BILAT. SWITCH	4016B
U10	991-041087-001	IC, CMOS QUAD BILAT. SWITCH	4016B
U11	991-041146-001	IC, DUAL OP AMP	4558
U12	991-041146-001	IC, DUAL OP AMP	4558
U13	991-041146-001	IC, DUAL OP AMP	4558
U14	991-042388-001	IC, DUAL VOLTAGE COMPARATOR	LM393
U15	991-043554-001	IC, LSTTL QUAD 2 INPUT AND	74LS08
U16	991-043532-001	IC, LSTTL QUAD 2 INPUT OR	74LS32
U17	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U18	991-042908-001	IC, DUAL BIFET OP AMP	LF353 (TL072)
U19	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U20	991-045870-001	IC, DUAL VC AMPLIFIER	CEM3360
U21	991-041146-001	IC, DUAL OP AMP	4558
U22	991-041146-001	IC, DUAL OP AMP	4558
U23	991-042388-001	IC, DUAL VOLTAGE COMPARATOR	LM393
U24	991-043554-001	IC, LSTTL QUAD 2 INPUT AND	74LS08
U25	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U26	991-042908-001	IC, DUAL BIFET OP AMP	LF353 (TLO72)
U27	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U28	991-045870-001	IC, DUAL VC AMPLIFIER	CEM3360
U29	991-041146-001	IC, DUAL OP AMP	4558
U30	991-042388-001	IC, DUAL VOLTAGE COMPARATOR	LM393
U31	991-043554-001	IC, LSTTL QUAD 2 INPUT AND	74LS08
U32	991-043532-001	IC, LSTTL QUAD 2 INPUT OR	74LS32
U33	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U34	991-042908-001	IC, DUAL BIFET OP AMP	LF353 (TL072)
U35	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U36	991-045870-001	IC, DUAL VC AMPLIFIER	CEM3360

996-045649-001 CONTOUR/GLIDE BOARD #3 (CONT'D)

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
U37	991-041146-001	IC, DUAL OP AMP	4558
U38	991-041146-001	IC, DUAL OP AMP	4558
U39	991-042388-001	IC, DUAL VOLTAGE COMPARATOR	LM393
U40	991-043554-001	IC, LSTTL QUAD 2 INPUT AND	74LS08
U41	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U42	991-042908-001	IC, DUAL BIFET OP AMP	LF353 (TLO72)
U43	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U44	991-045870-001	IC, DUAL VC AMPLIFIER	CEM3360
U45	991-041146-001	IC, DUAL OP AMP	4558
U46	991-042388-001	IC, DUAL VOLTAGE COMPARATOR	LM393
U47	991-043554-001	IC, LSTTL QUAD 2 INPUT AND	74LS08
U48	991-043532-001	IC, LSTTL QUAD 2 INPUT OR	74LS32
U49	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U50	991-042908-001	IC, DUAL BIFET OP AMP	LF353 (TL072)
U51	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U52	991-045870-001	IC, DUAL VC AMPLIFIER	CEM3360
U53	991-041146-001	IC, DUAL OP AMP	4558
U54	991-041146-001	IC, DUAL OP AMP	4558
U55	991-042388-001	IC, DUAL VOLTAGE COMPARATOR	LM393
U56	991-043554-001	IC, LSTTL QUAD 2 INPUT AND	74LS08
U57	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U58	991-042908-001	IC, DUAL BIFET OP AMP	LF353 (TLO72)
U59	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U60	991-045870-001	IC, DUAL VC AMPLIFIER	CEM3360
U61	991-041146-001	IC, DUAL OP AMP	4558
Q1-Q7	991-041064-001	TRANSISTOR, FET N-CHANNEL	2N4303
Q8-Q19	991-041051-002	TRANSISTOR, NPN SMALL SIG.	2N3904
CR1+CR6	919-041075-001	DIODE, SIGNAL, SILICON	1N4148
C1	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C2	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C3	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C4	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C5	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C6	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C7	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C8	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C9	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C10	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C11	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C12	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C13	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C14	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C15	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C16	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C17	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C18	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C19	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C20	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C21	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C22	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C23	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C24	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C25	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C26	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C27	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C28	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C29	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C30	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C31	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C32	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C33	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C34	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C35	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C36	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C37	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C38	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD

996-045649-001 CONTOUR/GLIDE BOARD #3 (CONT'D)

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
C39	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C40	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C41	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C42	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C43	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C44	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C45	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C46	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C47	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C48	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C49	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C50	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C51	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C52	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C53	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C54	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C55	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C56	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C57	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C58	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C59	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C60	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C61	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C62	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C63	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C64	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C65	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C66	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C67	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C68	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C69	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C70	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C71	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C72	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C73	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C74	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C75	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C76	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 NFD
C77	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C78	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C78	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C80	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C81	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C82	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C83	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C84	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C85	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C86	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C87	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C88	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C89	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C91	947-045008-102	CAPACITOR, CERAMIC TUBULAR	.001 UFD
R1-2	949-044333-002	RESISTORS, MATCHED PAIR 1%	100K,.01% SELECTED
R12-13	949-044333-002	RESISTORS, MATCHED PAIR 1%	100K,.01% SELECTED
R26	925-040275-004	POT, TRIM CARBON	10K GLIDE RNG C&D
R18-19	949-044333-002	RESISTORS, MATCHED PAIR 1%	100K,.01% SELECTED
R29-30	949-044333-002	RESISTORS, MATCHED PAIR 1%	100K,.01% SELECTED
R35-36	949-044333-002	RESISTORS, MATCHED PAIR 1%	100K,.01% SELECTED
R43	925-040275-004	POT, TRIM CARBON	10K GLIDE RNG E&F
R46-47	949-044333-002	RESISTORS, MATCHED PAIR 1%	100K,.01% SELECTED
R53	925-040275-004	POT, TRIM CARBON	10K TRNSPE OFFSET
R60	925-042526-003	POT, TRIM CERMET	10K TRNSPSE SCL
R77	925-040275-004	POT, TRIM CARBON	10K MONO GLD RNG
R128	925-040275-003	POT, TRIM CARBON	50K VCE MOD CNTR A
R131	925-040275-003	POT, TRIM CARBON	50K VCF O/S CNTR A
R161	925-040275-003	POT, TRIM CARBON	50K VCE MOD CNTR B
R164	925-040275-003	POT, TRIM CARBON	50K VCF O/S CNTR B

996-045649-001 CONTOUR/GLIDE BOARD #3 (CONT'D)

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
R190	925-040275-003	POT, TRIM CARBON	50K VCE MOD CNTR C
R193	925-040275-003	POT, TRIM CARBON	50K VCF O/S CNTR C
R219	925-040275-003	POT, TRIM CARBON	50K VCE MOD CNTR D
R222	925-040275-003	POT, TRIM CARBON	50K VCF O/S CNTR D
R248	925-040275-003	POT, TRIM CARBON	50K VCE MOD CNTR E
R251	925-040275-003	POT, TRIM CARBON	50K VCF O/S CNTR E
R277	925-040275-003	POT, TRIM CARBON	50K VCE MOD CNTR F
R280	925-040275-003	POT, TRIM CARBON	50K VCF O/S CNTR F

996-045652-001 DIGITAL BOARD #4

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(1)	908-045886-001	INSULATOR,FISH PAPER 6.4 X 16.1	COMMON ANALOG
P40	910-046058-008	HEADER, CIS .1" CNTRS. LOCKING	8 PIN
P41	910-046058-006	HEADER, CIS .1" CNTRS. LOCKING	6 PIN
P42	910-046058-005	HEADER, CIS .1" CNTRS. LOCKING	5 PIN
P47	910-046058-006	HEADER, CIS .1" CNTRS. LOCKING	6 PIN
P48A	910-046058-008	HEADER, CIS .1" CNTRS. LOCKING	8 PIN
P48B	910-046058-008	HEADER, CIS .1" CNTRS. LOCKING	8 PIN
P49	910-046058-003	HEADER, CIS .1" CNTRS. LOCKING	3 PIN
(1)	906-045188-008	SOCKET, IC DIP .3" CNTRS.	8 PIN
(10)	906-045188-014	SOCKET, IC DIP .3" CNTRS.	14 PIN
(15)	906-045188-016	SOCKET, IC DIP .3" CNTRS.	16 PIN
(3)	906-045188-020	SOCKET, IC DIP .3" CNTRS.	20 PIN
(7)	906-045188-024	SOCKET, IC DIP .6" CNTRS.	24 PIN
(1)	906-045188-028	SOCKET, IC DIP .6" CNTRS.	28 PIN
(2)	906-045188-040	SOCKET, IC DIP .6" CNTRS.	40 PIN
BT1	926-045312-001	BATTERY, LITHIUM	3 VOLT
Y1	921-045313-001	CRYSTAL, QUARTZ	4 MEGAHERTZ
K1	921-045141-001	RELAY, REED SPST	500 OHM COIL
Q1-Q3	991-041052-001	TRANSISTOR, PNP SMALL SIG	2N3906
CR1-CR3	919-041075-001	DIODE, SIGNAL	1N4148
CR4-CR9	919-042019-001	DIODE, RECTIFIER 1A/400PIV	1N4004
C1	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C2	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C3	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C4	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C5	946-040231-001	CAPACITOR, TANTALUM	1.5 UFD/20V
C6	947-045008-100	CAPACITOR, CERAMIC TUBULAR	10 PFD
C7	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C8	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C9	947-045008-100	CAPACITOR, CERAMIC TUBULAR	10 PFD
C10	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C11	946-041978-104	CAPACITOR, POLYESTER BOX	.01 UFD
C12	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C13	946-040231-002	CAPACITOR, TANTALUM	10 UFD/20V
C14	945-044465-008	CAPACITOR, ALUMINUM ELECT.	47 UFD/16V
C15	947-045011-103	CAPACITOR, MONOLITHIC	.1 UFD
C16	945-040209-014	CAPACITOR, ALUMINUM ELECT.	2.2 UFD/25V
C17	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C18	947-045008-471	CAPACITOR, CERAMIC TUBULAR	470 PFD
C19	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C20	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C21-C32	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD

996-045652-001 DIGITAL BOARD #4 (CONT'D)

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
U1	991-045306-001	IC, MICROPROCCESOR	Z-80 CPU
U2-U4	991-045307-XXX	IC, UVEPROM 4K BY 8, 2532	VARIOUS VERSIONS
U5	991-045530-001	IC, CMOS RAM 2K BY 8	6116LP
U6	991-045530-001	IC, CMOS RAM 2K BY 8	6116LP
U7	991-045530-001	IC, CMOS RAM 2X BY 8	6116LP
U9	991-043555-001	IC, LSTTL DECODER/DMUX	74LS138
U10	991-045867-001	IC, COUNTER/TIMER	Z-80 CTC
U11	991-043555-001	IC, LSTTL DECODER/DMUX	74LS138
U12	991-043552-001	IC, LSTTL QUAD 2 INPUT NOR	74LS02
U13	991-043577-001	IC, LSTTL QUAD 2 INPUT NAND	74LS00
U14	991-043553-001	IC, LSTTL HEX INVERTER	74LS04
U15	991-043520-001	IC, CMOS HEX SCHMITT TRIG.	40106B
U16	991-045299-001	IC, LSTTL DUAL D FLIP/FLOP	74LS74
U17	991-043555-001	IC, LSTTL DECODER/DMUX	74LS138
U18	991-043555-001	IC, LSTTL DECODER/DMUX	74LS138
U19	991-043555-001	IC, LSTTL DECODER/DMUX	74LS138
U20	991-043555-001	IC, LSTTL DECODER/DMUX	74LS138
U21	991-043553-001	IC, LSTTL HEX INVERTER	74LS04
U22	991-045549-001	IC, LSTTL QUAD 2 INPUT NAND	74LS26
U23	991-042388-001	IC, DUAL COMPARATOR	LF393
U24	991-041112-001	IC, VOLTAGE REGULATOR 5V	78M05C
U25	991-043532-001	IC, LSTTL QUAD 2 INPUT OR	74LS32
U26	991-045866-001	IC, CMOS HEX TRI-STATE BUF	4503B
U27	991-045866-001	IC, CMOS HEX TRI-STATE BUF	4503B
U28	991-045865-001	IC, LSTTL OCTAL D FLIP/FLOP	74LS377
U29	991-045864-001	IC, LSTTL OCTAL BUS TRNSCVR	74LS245
U30	991-045866-001	IC, CMOS HEX TRI-STATE BUF	4503B
U31	991-043550-001	IC, LSTTL DUAL 4-BIT CNTR	74LS393
U32	991-045865-001	IC, LSTTL OCTAL D FLIP/FLOP	74LS377
U33	991-045299-001	IC, LSTTL DUAL D FLIP/FLOP	74LS74
U34	991-043555-001	IC, LSTTL DECODER/DMUX	74LS138
U35	991-043555-001	IC, LSTTL DECODER/DMUX	74LS138

996-045655-001 DMUX BOARD #5

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(36)	906-045188-008	SOCKET, IC DIP .3" CNTRS.	8 PIN
(5)	906-045188-014	SOCKET, IC DIP .3" CNTRS.	14 PIN
(32)	906-045188-016	SOCKET, IC DIP .3" CNTRS.	16 PIN
(2)	906-045188-020	SOCKET, IC DIP .3" CNTRS.	20 PIN
P511	910-046058-006	HEADER, .1" CNTRS. LOCKING	6 PIN
P512	910-046058-004	HEADER, .1" CNTRS. LOCKING	8 PIN
P513	910-046058-004	HEADER, .1" CNTRS. LOCKING	4 PIN
P514	910-046058-006	HEADER, .1" CNTRS. LOCKING	6 PIN
P515A	910-046058-003	HEADER, .1" CNTRS. LOCKING	3 PIN
P515B	910-046058-003	HEADER, .1" CNTRS. LOCKING	3 PIN
P515C	910-046058-003	HEADER, .1" CNTRS. LOCKING	3 PIN
P515D	910-046058-003	HEADER, .1" CNTRS. LOCKING	3 PIN
P515E	910-046058-003	HEADER, .1" CNTRS. LOCKING	3 PIN
P515F	910-046058-003	HEADER, .1" CNTRS. LOCKING	3 PIN
P516	910-046058-010	HEADER, .1" CNTRS. LOCKING	10 PIN
P517	910-046058-004	HEADER, .1" CNTRS. LOCKING	4 PIN
P518	910-046058-007	HEADER, .1" CNTRS. LOCKING	7 PIN
P519	910-046058-008	HEADER, .1" CNTRS. LOCKING	8 PIN
P520	910-046058-006	HEADER, .1" CNTRS. LOCKING	6 PIN
P521	910-046058-006	HEADER, .1" CNTRS. LOCKING	6 PIN
P522	910-046058-006	HEADER, .1" CNTRS. LOCKING	6 PIN
U1	991-043559-001	IC, LSTTL OCTAL D F/F	74LS378
U2	991-045865-001	IC, LSTTL HEX D F/F	74LS377
U3	991-045356-001	IC, INTERFACE 12 BIT DAC	6012

996-045655-001 DMUX BOARD #5 (CONT'D)

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
U4	991-041101-001	IC, OP AMP	741
U5	991-042793-001	IC, OP AMP	LF351 (TLO71)
U6	991-042388-001	IC, DUAL VOLTAGE COMPARATOR	LM393
U7-U9	991-045305-001	IC, TTL HEX BUFFER/DRIVER	7417
U10-U17	991-041090-001	IC, CMOS 8 CHAN MULTIPLEXER	4051
U18-U49	991-042908-001	IC, DUAL BIFET OP AMP	LF353 (TLO72)
U50	991-045305-001	IC, TTL HEX BUFFER/DRIVER	7417
U51	991-043559-001	IC, LSTTL HEX D FLIP/FLOP	74LS378
U52	991-043559-001	IC, LSTTL HEX D FLIP/FLOP	74LS378
U53	991-045862-001	IC, TTL HEX INVERTER	7416
U54-U61	991-043518-001	IC, CMOS HEX D FLIP/FLOP	40174B
U62	991-041146-001	IC, DUAL OP AMP	4558
Q1-Q12	991-041052-002	TRANSISTOR, PNP SMALL SIG	2N3906
Q13	991-041051-002	TRANSISTOR, NPN SMALL SIG	2N3904
Q14	991-045872-001	TRANSISTOR, PNP MED POWER	TN2905
CR1	919-041078-002	DIODE, ZENER 6.2V/250MW	1N823
CR2	919-041075-001	DIODE, SIGNAL	1N4148
CR3	919-041075-001	DIODE, SIGNAL	1N4148
CR4	919-041349-004	DIODE, ZENER 8.2V/500MW	N5237A
C1	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C2	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C3	947-045008-101	CAPACITOR, CERAMIC TUBULAR	100 PFD
C4	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C5	947-045008-101	CAPACITOR, CERAMIC TUBULAR	100 PFD
C6	945-044465-003	CAPACITOR, ALUMINUM ELECT	10 UFD/25V
C7-C70	946-041978-103	CAPACITOR, POLYESTER BOX	.01 UFD
C71	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C72	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C73-C75	945-044465-003	CAPACITOR, ALUMINUM ELECT	10 UFD/25V
C76-C103	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
R4	925-042389-003	POT, TRIM CERMET	1K +10V ADJ
R8	925-042389-002	POT, TRIM CERMET	10K FULL SCALE ADJ
R10	925-042389-006	POT, TRIM CERMET	100K ZERO ADJ

996-045658-001 RIGHT SIDE CONTROL BOARD #6

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(1)	906-045188-008	SOCKET, IC DIP .3" CNTRS.	8 PIN
(1)	906-045188-014	SOCKET, IC DIP .3" CNTRS.	14 PIN
(7)	906-045188-016	SOCKET, IC DIP .3" CNTRS.	16 PIN
(2)	910-042392-008	HEADER, CIS RT ANGLE	8 PIN
(1)	967-045830-002	L BRACKET, BOTTOM RSC	BOARD STIFFENER
(1)	967-045830-004	L BRACKET, TOP RSC	BOARD STIFFENER
(30)	975-045466-001	SPRING, COMPRESSION	FRONT PANEL SWITCH
(30)	964-044082-001	BUTTON, DARK GRAY	FRONT PANEL SWITCH
(30)	960-045861-001	SWITCH, CONTACT SPRING	FRONT PANEL SWITCH
(30)	960-045831-002	SWITCH, CONTACT BUTTON	FRONT PANEL SWITCH
U1	991-045866-001	IC, CMOS HEX TRISTATE BUFF	4053B
U2	991-043559-001	IC, LSTTL HEX D TYPE F/F	74LS378
U3	991-041090-001	IC, CMOS 8 CHANNEL MUX	4051B
U4	991-041090-001	IC, CMOS 8 CHANNEL MUX	4051B
U5	991-041090-001	IC, CMOS 8 CHANNEL MUX	4051B
U6	991-045305-001	IC, TTL HEX BUFFER/DRIVER	7417
U7	991-041176-001	IC, DUAL OP AMP	4558

996-045658-001 RIGHT SIDE CONTROL BOARD #6 (CONT'D)

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
Q1-Q4	991-041052-002	TRANSISTOR, PNP SMALL SIG.	2N3906
Q5	991-045215-001	TRANSISTOR, NPN HI CURRENT	TN2219
(30)	939-045874-001	LED, HIGH BRIGHTNESS	RED
C1	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C2	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C3	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C4	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C5	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C6	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C7-C33	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
R22	925-045880-001	POT, ROTARY PC MTG LINEAR	10K PW 1
R23	925-045881-001	POT, ROTARY 12 TURN LINEAR	10K FREQ 2
R24	925-045880-001	POT, ROTARY PC MTG LINEAR	10K PW 2
R25	925-045881-001	POT, ROTARY 12 TURN LINEAR	10K FREQ 3
R26	925-045880-001	POT, ROTARY PC MTG LINEAR	10K PW 3
R27-R42	925-045880-001	POT, ROTARY PC MTG LINEAR	10K VARIOUS
R43	925-045880-002	POT, ROTARY PC MTG AUDIO	5K MASTER VOLUME
R44	925-045880-002	POT, ROTARY PC MTG AUDIO	5K HEADPHONE VOLUME

996-045661-001 LEFT SIDE CONTROL BOARD #7

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(1)	906-045188-014	SOCKET, IC DIP .3" CNTRS.	14 PIN
(8)	906-045188-016	SOCKET, IC DIP .3" CNTRS.	16 PIN
(4)	906-045188-020	SOCKET, IC DIP .6" CNTRS.	20 PIN
(1)	910-042392-003	HEADER, CIS RT ANGLE	3 PIN
(1)	910-042392-007	HEADER, CIS RT ANGLE	7 PIN
(1)	910-042392-008	HEADER, CIS BOTTOM MOUNTED	8 PIN
(1)	967-045830-001	"L" BRACKET, BOTTOM LSC	BOARD STIFFENER
(1)	967-045830-003	"L" BRACKET, TOP LSC	BOARD STIFFENER
(48)	975-045466-001	SPRING, COMPRESSION	FRONT PANEL SWITCH
(32)	964-044082-001	BUTTON, DARK GRAY	FRONT PANEL SWITCH
(48)	960-045861-001	SWITCH, CONTACT SPRING	FRONT PANEL SWITCH
(48)	960-045861-002	SWITCH, CONTACT BUTTON	FRONT PANEL SWITCH
SW33	964-044082-112	BUTTON, SWITCH LIGHT GREY	"A"
SW34	964-044082-113	BUTTON, SWITCH LIGHT GREY	"B"
SW35	964-044082-114	BUTTON, SWITCH LIGHT GREY	"C"
SW36	964-044082-115	BUTTON, SWITCH LIGHT GREY	"D"
SW37	964-044082-105	BUTTON, SWITCH LIGHT GREY	"3"
SW38	964-044082-108	BUTTON, SWITCH LIGHT GREY	"6"
SW39	964-044082-111	BUTTON, SWITCH LIGHT GREY	"9"
SW40	964-044082-002	BUTTON, SWITCH LIGHT GREY	" "
SW41	964-044082-104	BUTTON, SWITCH LIGHT GREY	"2"
SW42	964-044082-107	BUTTON, SWITCH LIGHT GREY	"5"
SW43	964-044082-110	BUTTON, SWITCH LIGHT GREY	"8"
SW44	964-044082-101	BUTTON, SWITCH LIGHT GREY	"0"
SW45	964-044082-102	BUTTON, SWITCH LIGHT GREY	"1"
SW46	964-044082-106	BUTTON, SWITCH LIGHT GREY	"4"
SW47	964-044082-109	BUTTON, SWITCH LIGHT GREY	"7"
SW48	964-044082-002	BUTTON, SWITCH LIGHT GREY	" "
U1	991-045950-001	IC, LSTTL OCTAL D F/F	74LS273
U2	991-045876-001	IC, TRANSISTOR ARRAY	2074
U3	991-045876-001	IC, TRANSISTOR ARRAY	2074
U4	991-045865-001	IC, LSTTL OCTAL D F/F	74LS377
U5	991-045865-001	IC, LSTTL OCTAL D F/F	74LS377

996-045661-001 LEFT SIDE CONTROL BOARD #7 (CONT'D)

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
U6	991-045865-001	IC, LSTTL OCTAL D F/F	74LS377
U7	991-045866-001	IC, CMOS HEX 3 STATE BUFF	4503B
U8	991-043559-001	IC, LSTTL HEX D F/F	74LS378
U9	991-041090-001	IC, CMOS 8 CHANNEL MUX	4051B
U10	991-041112-004	IC, VOLT REG +6 VOLT	78M06
U11	991-041112-004	IC, VOLT REG +6 VOLT	78M06
U12	991-041112-004	IC, VOLT REG +6 VOLT	78M06
U13	991-045305-001	IC, TTL HEX BUFFER	7417
U14	991-042388-001	IC, DUAL COMPARATOR	LM393
Q1-Q18	991-041052-002	TRANSISTOR, PNP SMALL SIG.	2N3906
(33)	939-045874-001	LED, HIGH BRIGHTNESS	RED
C1	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C2	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C3-C16	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C17	945-040209-019	CAPACITOR, ALUMINUM ELECT.	220 UFD/16V
C18	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C19	945-040209-019	CAPACITOR, ALUMINUM ELECT.	220 UFD/16V
C20-C22	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C23	945-040209-019	CAPACITOR, ALUMINUM ELECT.	220 UFD/16V
C24	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C25	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C26	945-040209-019	CAPACITOR, ALUMINUM ELECT.	220 UFD/16V
C27	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C28	946-041978-472	CAPACITOR, POLYESTER BOX	4.7 NFD
R61	925-045880-001	POT, ROTARY PC MTG. LINEAR	10K GLIDE
R62	925-045880-001	POT, ROTARY PC MTG. LINEAR	10K BEND AMT
R63	925-045880-001	POT, ROTARY PC MTG. LINEAR	10K MOD AMT
R64	925-045880-001	POT, ROTARY PC MTG. LINEAR	10K FT. PED. 1 AMT
R65	925-045880-001	POT, ROTARY PC MTG. LINEAR	10K FT. PED. 2 AMT
R66	925-045880-001	POT, ROTARY PC MTG. LINEAR	10K MOD RATE
R67	925-045880-001	POT, ROTARY PC MTG. LINEAR	10K VOICE MOD OSC 3
R68	925-045880-001	POT, ROTARY PC MTG. LINEAR	10K VOICE MOD VCF
R69	925-045880-001	POT, ROTARY PC MTG. LINEAR	10K TUNE

996-045664-001 DISPLAY BOARD #8

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(2)	904-041406-009	WASHER, FLAT FIBRE	#4 X 9/32"
(2)	816-040039-006	SCREW, SELF TAPPING	#6B X 3/8"
(2)	902-042525-001	NUT, TINNERMAN "U" TYPE	#6
(2)	910-040299-001	HEADER, CIS	1 PIN
U1	991-043559-001	IC, LSTTL HEX D FLIP/FLOP	74LS378
U2	991-041097-001	IC, TTL BCD 7 SEG DECODER	7447
U3	939-042633-002	DISPLAY, 7 SEGMENT, 2 DIGIT	MAN6610
U4	939-045873-001	DISPLAY, 8 CHARACTER, ALPHA	LT1604
Q1	991-041057-001	TRANSISTOR, PNP 60V/2A	MPSU55
Q2	991-041057-001	TRANSISTOR, PNP 60V/2A	MPSU55
C1	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD

996-045667-001 JACK BOARD #9

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
P91	910-040299-008	HEADER, CIS .1" CNTRS.	8 PIN
P92	910-040299-005	HEADER, CIS .1" CNTRS.	5 PIN
J1	910-045552-001	JACK, PHONE, 1/4" 2CD	UNBALANCE OUTPUT
J2	910-045552-003	JACK, PHONE, 1/4" N/C	FOOT PEDAL #1
J3	910-045552-003	JACK, PHONE, 1/4" N/C	FOOT PEDAL #2
J4	910-045552-001	JACK, PHONE, 1/4" 2CD	EXT. SYNTH CV
J5	910-045552-001	JACK, PHONE, 1/4" 2CD	V-GATE OUT
J6	910-045552-001	JACK, PHONE, 1/4" 2CD	S-TRIG OUT
U1	991-041146-001	IC, DUAL OP AMP	4558
R3	925-042526-004	POT, TRIM CERMET	25K(S) SCALE ADJ
R6	925-042526-003	POT, TRIM CERMET	10K(R) RANGE ADJ
J7	910-041306-001	JACK, PHONE MONO 1/4" 2CD	RELEASE
J8	910-041306-001	JACK, PHONE MONO 1/4" 2CD	HOLD
J9	910-041306-001	JACK, PHONE MONO 1/4" 2CD	PROGRAM ADVANCE
J10	910-041306-001	JACK, PHONE MONO 1/4" 2CD	PROGRAM BACKSTEP
J11	910-041306-002	JACK, PHONE MONO 1/4" N/C	CLOCK IN
J12	910-041306-005	JACK, PHONE STEREO 1/4" 3CD	EARPHONE
J13	910-041306-001	JACK, PHONE MONO 1/4" 2CD	GLIDE
J14	910-041306-001	JACK, PHONE MONO 1/4" 2CD	FROM TAPE
J15	910-041306-001	JACK, PHONE MONO 1/4" 2CD	REMOTE
J16	910-041306-001	JACK, PHONE MONO 1/4" 2CD	TO TAPE
S3	910-041451-001	JACK, 3 PIN XLR	BALANCED OUTPUT
T1	955-045879-001	TRANSFORMER, AUDIO DRIVER	600 OHM BAL. LINE

996-045667-001 OCTAVE TRANSPOSE BOARD #10

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(2)	960-045861-001	SWITCH, CONTACT SPRING	SWITCH, LHC
(2)	960-045861-002	SWITCH, CONTACT BUTTON	SWITCH, LHC
(2)	973-041409-036	SPACER, NYLON	#8 X 7/16"
(2)	975-045466-001	SPRING, COMPRESSION	SWITCH, LHC
SW1	964-044082-103	BUTTON, LIGHT GRAY	"-1"
SW2	964-044082-101	BUTTON, LIGHT GRAY	"0"
LED1	939-045874-001	LED, HIGH BRIGHTNESS	RED
LED2	939-045874-001	LED, HIGH BRIGHTNESS	RED
U1	991-042388-001	IC, DUAL VOLTAGE COMPARATOR	LM393

ACCESSORY BOARDS 11 & 12

RESERVED FOR FUTURE EXPANSION

997-045884-001 POWER SUPPLY BOARD #13

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(3)	906-045188-014	SOCKET, IC DIP 14 PIN	FOR 723 ICs
(4)	906-042676-001	SOCKET, TIP TRANSISTOR	FOR TIP 41S
(4)	903-042674-001	SCREW, SELF-TAPPING	4-40 X 1"
(4)	908-042674-001	INSULATOR, MICA	PASS TRANSISTORS
(4)	904-042729-001	WASHER, SHOULDER INSULATED	PASS TRANSISTORS
(1)	968-045928-001	HEATSINK, COUPLER PLATE	ALUMINUM
P131	910-042533-015	HEADER, .156" CTRS.	15 PIN NON-LOCKING
P132	910-042531-003	HEADER, .156" CTRS.	3 PIN LOCKING
P133	910-042531-003	HEADER, .156" CTRS.	3 PIN LOCKING
P134	910-042531-001	HEADER, .156" CTRS.	3 PIN LOCKING
U1	991-041484-001	IC, VOLTAGE REGULATOR DIP	723C
U2	991-041484-001	IC, VOLTAGE REGULATOR DIP	723C
U3	991-041484-001	IC, VOLTAGE REGULATOR DIP	723C
Q1	991-042663-001	TRANSISTOR, NPN 40V/6A	TIP41
Q2	991-041056-001	TRANSISTOR, NPN 60V/2A	MPS U05
Q3	991-042663-001	TRANSISTOR, NPN 40V/6A	TIP41
Q4	991-041056-001	TRANSISTOR, NPN 60V/2A	MPSU05
Q5	991-042663-001	TRANSISTOR, NPN 40V/6A	TIP41
Q6	991-042663-001	TRANSISTOR, NPN 40V/6A	TIP41
Q7	991-041056-001	TRANSISTOR, NPN 60V/2A	MPS U05
CR1-CR4	919-041157-001	DIODE, RECTIFIER 3A/200PIV	MR502
CR5	919-041255-002	DIODE, ZENER 22V/1WATT	1N4748A
CR6	919-042019-001	DIODE, RECTIFIER 1A/400PIV	1N4004
CR7	919-042019-001	DIODE, RECTIFIER 1A/400PIV	1N4004
CR8-CR11	919-041157-001	DIODE, RECTIFIER 3A/200PIV	MR502
CR12	919-041255-002	DIODE, ZENER 22V/1WATT	1N4748A
CR13	919-042019-001	DIODE, RECTIFIER 1A/400PIV	1N4004
CR14	919-042019-001	DIODE, RECTIFIER 1A/400PIV	1N4004
CR15	919-041157-001	DIODE, RECTIFIER 3A/200PIV	MR502
CR16	919-041157-001	DIODE, RECTIFIER 3A/200PIV	MR502
CR17	919-041157-001	DIODE, RECITFIER 3A/200PIV	MR502
CR18	919-041157-001	DIODE, RECTIFIER 3A/200PIV	MR502
CR19	919-041255-002	DIODE, ZENER 22V/1WATT	1N4748A
CR20	919-042019-001	DIODE, RECTIFIER 1A/400PIV	1N4004
C1	945-040209-043	CAPACITOR, ALUMINUM ELECT.	3300 UFD/35V
C2	947-042020-471	CAPACITOR, CERAMIC DISC.	470 PFD
C3	945-040209-042	CAPACITOR, ALUMINUM ELECT.	1000 UFD/16V
C4	945-040209-043	CAPACITOR, ALUMINUM ELECT.	3300 UFD/35V
C5	947-042020-471	CAPACITOR, CERAMIC DISC.	470 PFD
C6	945-040209-007	CAPACITOR, ALUMINUM ELECT.	470 UFD/35V
C7	945-040209-037	CAPACITOR, ALUMINUM ELECT.	4700 UFD/16V
C8	947-042020-471	CAPACITOR, CERAMIC DISC.	470 PFD
C9	945-040209-007	CAPACITOR, ALUMINUM ELECT.	470 UFD/35V
R8	925-042526-001	POT, TRIM CERMET	1K +15V ADJ
R19	925-042526-001	POT, TRIM CERMET	1K -15V ADJ
R33	925-042526-001	POT, TRIM CERMET	1K +5V ADJ

MEMORYMOOG PLUS SEQUENCER OPERATION

THIS SECTION OF THE MANUAL SHOWS YOU HOW TO USE THE MEMORYMOOG PLUS SEQUENCER. FIRST, THE GENERAL ARCHITECTURE OF THE SEQUENCER IS DISCUSSED. FOLLOWING THIS, A SERIES OF TUTORIALS SHOWS STEP-BY-STEP WHICH BUTTONS TO PUSH TO CREATE, STORE, PLAY, MERGE, GROUP AND LOOP SEQUENCES.

MEMORYMOOG PLUS SEQUENCER ARCHITECTURE

The Memorymoog Plus has two independent sequencers:

1. The polyphonic mode plays from 1 to 6 internal Memorymoog Plus voices, as specified by the performer.

2. The monophonic mode plays an external monophonic instrument connected to the EXTERNAL SYNTHESIZER OUT jacks on the rear of the Memorymoog Plus.

Both sequencers are driven by the same clock and can be used simultaneously.

Either sequencer is programmed/operated by pressing SYSTEM CONTROLLER buttons, and the double-function MODULATION/SEQUENCER buttons. The rear panel SEQUENCER/MIDI jacks provide SEQUENCER START/STOP using a footswitch, CLOCK IN and OUT for master/slave relationships with external drum machines, CLOCK DISABLE (necessary for some brands of drum machines), and CLICK OUT for creating a click track. In order to ensure compatability with a wide range of drum machines/synchronizers, the clock rate is switchable on the rear panel. (LOW, MED, and HIGH are 96, 192, and 384 cycles per measure respectively. This equates to 24, 48, and 96 cycles per "quarter note.") The new rear panel also houses the MIDI interface section.

There are six sequencer memory locations represented by buttons in the MODULATION/SEQUENCER section labelled 1-6. Each of these memory locations can store both:

A polyphonic sequence.

A monophonic sequence.

Three of these locations, buttons 1-3 labelled SEQ/MRG can store a MERGE, a potentially complicated musical pattern comprising several sequences that may themselves be repeated.

The amount of memory available to each sequence depends on the way you store information. Realtime free polyphony combining chords and lines is less memory efficient than entering chords and/or notes in the STEP mode. If you should find that a single sequence does not provide enough memory to hold your song, it is possible to connect two or more sequence memories together to create a longer memory, as we shall see later.

Polyphonic memory is approximately 5250 notes in step mode and 4000 notes in real time. A six note chord does not necessarily take up six

times as much memory as a single note however, since data is compacted. Experience will tell you system limits.

Monophonic memory is 1120 notes in step mode and 560 in real time.

All display "prompts," or messages displayed in the SYSTEM CONTROLLER section are indicated in the tutorials below with quotation marks; e.g. "VOICES 6."

ALL RESPONSES TO SYSTEM CONTROLLER PROMPTS EXCEPT "START" ARE DONE USING THE SYSTEM CONTROLLER KEYPAD.

( ) SEQUENCER [ ] CONTROLLER

SEQUENCER TUTORIALS

IN THIS SECTION YOU WILL BE ASKED TO PRESS SWITCHES AND READ THE DISPLAY, WHICH WILL "PROMPT" YOU, TELLING YOU WHAT TO DO. IF THE BUTTON YOU ARE ASKED TO PRESS IS IN THE SEQUENCER SECTION, ITS NAME/NUMBER IN THIS MANUAL WILL BE ENCLOSED BY THE "GREATER THAN, LESS THAN" SYMBOLS LIKE THIS:

⟨RECORD⟩ THIS MEANS "PRESS THE RECORD SWITCH."

SOMETIMES THE BUTTON TO BE PRESSED IS IN THE SYSTEM CONTROLLER KEYPAD SECTION. BUTTONS IN THIS SECTION WILL BE ENCLOSED BY BRACKETS, LIKE THIS:

[ENTER] THIS MEANS "PRESS THE ENTER SWITCH."

IT IS MOST IMPORTANT TO REMEMBER THIS WHEN DEALING WITH NUMBERED BUTTONS, SINCE NUMBERS 1-6 OCCUR IN TWO SECTIONS OF THE INSTRUMENT. FOR EXAMPLE:

⟨1⟩ MEANS "PRESS BUTTON 1 IN THE MODULATION/SEQUENCER SECTION."

[1] MEANS "PRESS BUTTON 1 IN THE SYSTEM CONTROLLER SECTION."

SOME MORE EXAMPLES:

[C], [C]	"PRESS BUTTON C IN THE SYSTEM CONTROLLER SECTION TWICE."
[ENTER]	"PRESS ENTER BUTTON IN SYSTEM CONTROLLER."
⟨START⟩	"PRESS START/STOP BUTTON IN SEQUENCER SECTION."
⟨STOP⟩	"PRESS START/STOP BUTTON IN SEQUENCER SECTION."
⟨3⟩	"PRESS BUTTON 3 IN SEQUENCER SECTION."
[3]	"PRESS BUTTON 3 IN SYSTEM CONTROLLER SECTION."

HOW TO RECORD/PLAY A POLYPHONIC SEQUENCE IN REAL TIME: A TUTORIAL

ACTION:	PURPOSE/RESULT:
[C], [C], [ENTER]	Places instrument in the polyphonic "SEQUENCE" mode; see display. (Repeat step if display says "MOOG.")

(IN SEQUENCE MODE THE LIGHT BY THE SEQUENCE BUTTON COMES ON. Since the sequencer comes on in the polyphonic mode, the MONO light will be OFF when you access the sequencer mode.)

(RECORD)	Enables record mode. (NOTE: If the RECORD light fails to come on, the instrument may have been purposely "disabled" to prevent accidentally recording over valuable sequences. Do a [C], [8] two-switch entry and see if the display says "DISABLED." If it does, you can defeat this by entering 0000 on the keypad and pressing [ENTER]. Now you can record).
(1)	Selects storage location #1 for your sequence.
(START)	The START light does not come on, but the display prompts you:
"TEMPO - "	Prompts you to enter on the SYSTEM CONTROLLER keypad a tempo between 60 and 240 (in Metronome Marking beats per minute).
[ENTER]	Enters Tempo value currently in display.
"BEATS - "	Prompts you to enter the number of beats per measure. You may change this value, using the SYSTEM CONTROLLER keypad selecting one of the possible values (1,2,3,4,6,8).
[ENTER]	Enters number shown in display as beats per measure.
"VOICES - "	Prompts you to enter the maximum number of Memorymoog voices (notes) you wish to use during the sequence. Use the SYSTEM CONTROLLER keypad to select 1-6 voices.
[ENTER]	Enters number shown in display as number of voices you wish to use in this sequence. The remaining voices are available to be

played from the keyboard during the sequence.

"START" — Display prompts you to press START button.

⟨START⟩ — The countdown to begin recording starts. The display will count a "measure for nothing" and display will count beats for you, synchronized with audible clicks if you are monitoring CLICK OUT.

PLAY YOUR SEQUENCE!

⟨STOP⟩ — Stops recording and defines the point at which a "looped" (repeated) sequence will end (and begin).

Comment: This tutorial reveals some basics necessary to use the sequencer. The keystroke entry [C], [C], [ENTER] "toggles," or alternates the front panel between "MOOG" and "SEQUENCE" modes of operation. The MOOG mode uses the MODULATION/SEQUENCER switches to program modulations. In the SEQUENCE mode, these switches control sequencer functions.

Also, note that in RECORD mode, pushing START the first time causes the display to prompt you, asking for information entered by the SYSTEM CONTROLLER keypad. Push START a second time and the recording process begins. The "measure for nothing" is a "kickoff" to help you feel the tempo. If you are listening to CLICK OUT on the rear panel, you'll hear one measure of clicks before recording starts, and clicks will continue as you record.

The sequencer comes up in the polyphonic mode (the MONO light is out). If you want to create a monophonic sequence, you must do so with the MONO light on.

HOW IS THE LOOP POINT OF A SEQUENCE DEFINED? By pressing STOP. But it is important to realize that a sequence cannot contain a partial measure, even at its end. If you press STOP late--during the first half of an unwanted measure, the extra time will be dropped and that measure will NOT become part of the sequence.

If you press too late--during the last half of the late measure--enough rests will be added to include this added measure at the end of the sequence. This lets you create a sequence that has rests, or silence at its end before it repeats.

WHAT IF YOUR SEQUENCE IS TOO LONG TO FIT INTO A SINGLE SEQUENCE LOCATION? Connect two or more sequence memories when SEQUENCE and RECORD lights are on: press the LOWER of two numbered buttons FIRST and HOLD IT DOWN, then the HIGHER number LAST (order is important!) Those two memories AND ANY THAT FALL BETWEEN THEM will become one memory, having a "name" that is the lowest number pressed. If you connect memories 1,2, and 3 together, they will collectively become location number "1;" if you try to play sequence 2 (or 3) the display will show "NO SEQ 2" (or 3), indicating that several memories have been connected. This connection is made only after the location has

been recorded into.

Now, let's play this poly sequence you have created:

⟨RECORD⟩	Necessary to turn RECORD mode off.
⟨START⟩	The sequence will play as recorded. It will loop automatically from the point you stopped it during recording.

Comment: It is easy to play a sequence back after you just recorded one, since you are already in the SEQUENCE mode, and have indicated the recording/playback location number. But let's review the general case for playing back a sequence making no prior assumptions:

PLAYBACK A POLYPHONIC SEQUENCE: GENERAL RULES

1. Must be in "SEQUENCE" mode. ⟨C⟩, [C], [ENTER] if not).

2. SEQUENCE light must be ON. ⟨SEQUENCE⟩ if not.

3. MONO light must be OFF. ⟨MONO⟩ if not.

4. The desired sequence location number must be selected. ⟨1⟩ or ⟨2⟩ or ⟨3⟩,. . . ⟨6⟩.

5. RECORD light must be OFF. ⟨RECORD⟩ if not.

6. Must ⟨START⟩ to begin playback.

7. The RATE knob in the MODULATION/SEQUENCER section does not affect the playback tempo unless the knob is moved, similar to any Memorymoog Plus edit. However, a new tempo for playback can be entered by going to the EDIT mode as follows:

CHANGING PLAYBACK TEMPO: THE EDIT MODE

(Must be in SEQUENCE mode)

⟨EDIT⟩	Calls up edit mode.
⟨RECORD⟩	Allows "recording" of edits you wish to make in TEMPO, and/or BEATS and VOICES.
⟨START⟩	(Begins with prompt for TEMPO.)

"TEMPO - "

[USE KEYPAD TO ENTER NUMBER BETWEEN 60 AND 240 FOR TEMPO]

[ENTER]	(Press the ENTER key to enter the new tempo rate.)

"BEATS - "

[ENTER] (Press ENTER to go to next prompt.)

"VOICES - "

[ENTER] (Press ENTER to exit prompts). Exit routine. RECORD light goes off.

(START) Starts sequence with edited (changed) tempo.

Comment: The most obvious use of the EDIT mode is recording at a slower tempo (e.g. 60), then going to the EDIT mode to speed up the playback. Only the tempo will change--not pitch--unlike a tape recorder.

When playing back any sequence, when you press START, the playback tempo will be determined by the most recent value you entered for tempo when prompted by the display in the RECORD or EDIT modes. If you record at a given tempo, and do not edit (change) that tempo, then recording and playback will be at the same tempo.

The RATE knob works only on playback. Playback tempo is electronically "centered," or given the value you entered on the keypad. If you move the RATE knob, the tempo will be edited and jump to the tempo determined by the RATE knob. So it makes sense to leave the RATE knob physically centered at the "5" position, so you can make a smooth change, rather than a jump in tempo.

While it is certainly possible to edit BEATS and VOICES while in the EDIT mode, this should be done thoughtfully. For instance if you record six voices and edit the VOICES prompt to play back only three, the Memorymoog Plus will follow your instructions explicitly. The instrument cannot possibly anticipate WHICH notes you consider important musically, and the results may be musically unpredictable. Also, if you edit BEATS from a sequence featuring an odd number to playback with an even number, or vice versa, the looping of sequences may be timed peculiarly. New musical uses may be discovered, but the player is advised that editing of BEATS and VOICES for playback be done with awareness of possibly unusual results.

If you choose, you can allocate fewer than 6 voices for a poly sequence and play the remaining voices from the keyboard while the sequence plays. When you leave only 1 voice for the keyboard, it is advisable to press the MONO switch FOUND TO THE LEFT OF THE SYSTEM CONTROLLER SECTION (light ON).

THIS ENDS THE "RECORD/PLAY A POLYPHONIC SEQUENCE" TUTORIAL.

RECORD (REAL TIME)/PLAY A MONOPHONIC SEQUENCE: A TUTORIAL

The monophonic sequencer works with an external monophonic synthesizer. This instrument should be connected to the Memorymoog Plus as follows:

CONNECTING AN EXTERNAL SYNTHESIZER

--Connect Memorymoog Plus V-GATE or S-TRIG output to external synthesizer trigger or gate input.

--Connect Memorymoog Plus CONTROL VOLT output to the oscillator control input of the external synth.

--Put KB OUT switch on Memorymoog Plus ON. (Must be on to drive external synthesizer).

--Depress lowest note (or zero volt key) on the external keyboard. Hit the lowest key on the Memorymoog Plus and tune the R (range) trimmer to zero beats. Hit the highest note on the Memorymoog Plus and tune the S (scale) trimmer to zero beats. Repeat low/high note tuning until satisfactory.

RECORDING THE MONO SEQUENCE

MAKE SURE THE KB OUT LIGHT IS ON FOR ALL PROGRAMS THAT YOU WISH TO USE IN A MONO SEQUENCE. ONLY WHEN THIS LIGHT IS ON CAN AN EXTERNAL INSTRUMENT BE HEARD. TO STORE A PROGRAM WITH THIS LIGHT ON, SEE PAGE 19 OF YOUR OWNER'S MANUAL.

(MONO)	Enable mono sequencer; MONO light ON.
(RECORD)	Go to record mode; RECORD light ON.
(1...6)	Select a storage location for your sequence.
(START)	Starts prompts.
"TEMPO - "	TEMPO prompt displayed in window. Enter tempo in M.M. markings from 60-240 on the SYSTEM CONTROLLER keypad.
[ENTER]	Enters tempo currently displayed.
"BEATS - "	BEATS prompt in display window. Enter the number of beats per measure you desire. Choose from these possibilities: 1,2,3,4,6,8 and enter on the SYSTEM CONTROLLER keypad.
[ENTER]	Enters number shown in display for beats per measure.
"START - "	Display prompts you to press START.
(START)	As before, you get a "measure for nothing" countdown in the display.
(PLAY MONO SEQUENCE ON MEMORYMOOG PLUS KEYBOARD.)	
(STOP)	Hit stop at end of the last measure to stop (also the "loop" point). WE suggest you use footswitch connected to START/STOP jack on SEQUENCER/MIDI rear panel plate.

PLAYING BACK THE SEQUENCE:

MAKE SURE THE KB OUT LIGHT IS ON.

⟨RECORD⟩	Leave RECORD mode (light OFF).
⟨START⟩	Start playback.

PLAYING A MONO SEQUENCE: GENERAL RULES

KB OUT SWITCH ON MEMORYMOOG PLUS MUST BE ON.

1. Must be in SEQUENCE mode. [C], [C], [ENTER] if not.
2. SEQUENCE light must be ON. ⟨SEQUENCE⟩ if not.
3. MONO light must be ON. ⟨MONO⟩ if not.
4. RECORD light must be OFF. ⟨RECORD⟩ if not.
5. Desired sequence location must be selected ⟨1⟩ . . . ⟨6⟩.
6. ⟨START⟩ to begin playback.
7. The RATE knob will affect tempo only if moved, as above.

THIS ENDS THE "RECORD/PLAYBACK MONO SEQUENCE" TUTORIAL.

RECORDING POLY, THEN MONO FOR SIMULTANEOUS PLAYBACK

(Record poly sequence; see above.)

(Connect external synth to SYNTHESIZER OUT jacks.)

Press KB OUT	(Light must be ON).
⟨MONO⟩*	*(Light must be OFF).
⟨1--6⟩	(Press location number of poly sequence.)
⟨MONO⟩	(Light must be ON).
⟨RECORD⟩	Prepare to record mono sequence.
⟨1--6⟩	Press location number of the mono sequence. This location does not have to have the same number as the poly sequence has.

⟨START⟩	Display prompts.
"TEMPO - "	
[ENTER]	(Accepts current value).
"BEATS - "	
[ENTER]	(Accepts current value).
"START"	
⟨START⟩	Play mono sequence on Memorymoog Plus keyboard while listening to poly sequence.
⟨STOP⟩	Hit stop when finished.

Comment: You "default" through the prompts, TEMPO, BEATS, by hitting [ENTER], [ENTER]. (NOTE: When you playback a poly and mono sequence simultaneously, the values for the prompts for the poly sequence will be adopted by the mono sequence, so the sequences will stay in sync.) The mono prompts can be programmed if you plan to play the mono sequence by itself, that is, not simultaneously with a poly sequence. But regardless of the prompt values of a mono sequence, it will adopt the prompt values of the poly sequence if you play the two simultaneously.

Poly and mono sequences may be recorded simultaneously, just as you can play both polyphonically--with the Memorymoog Plus--and monophonically--driving an external instrument--simultaneously. You must place each sequencer into RECORD mode, and specify a location for each sequence. Always set up the poly sequence first, then mono. Because going to poly mode clears the playback/record status.

PLAYBACK POLY AND MONO SIMULTANEOUSLY

⟨RECORD⟩*	*(Light must be OFF.)
⟨MONO⟩*	*(Light must be OFF to be in poly mode).
⟨1--6⟩	Storage location of desired poly sequence.
⟨MONO⟩	(Light must be ON to enable mono sequence selection.)
⟨1--6⟩	Storage location of desired mono sequence. Poly and mono sequence numbers do not have to be the same.
⟨START⟩	Combined sequences will repeat indefinitely. During playback of a combined poly/mono sequence, the MONO light will flash.

PROGRAM ADVANCES DURING A SEQUENCE;

TONE COLOR ON-THE-FLY: A TUTORIAL

Program advances are used normally with the Memorymoog Plus to step to new programs by pressing a footswitch. It is possible to include such program advances within a sequence; to make part of the sequence sound one tone color and another part an entirely different sound. This specification of Program advances is done during a special "one-time" playback of the sequence during which you press the "A" (Advance) button, or step on a footswitch connected to the PROGRAM ADVANCE jack on the rear panel.

Program advances stored within a sequence are nothing more than that. Just an indication of when "an advance" is to take place. It is up to the performer to specify WHICH program chain is to be used, and you must also program WHICH programs are in that chain AND IN WHAT ORDER. These are the same program chains used in normal playing, so it is suggested that some chains be dedicated to sequencer use (6-9?), and others for ordinary Program advance use when not in the sequencer mode. Otherwise, changes you make in Program chains while in sequencer mode will affect the other "MOOG" mode.

Let's assume you now have a poly sequence stored in location 1.

Let's see how to use a Program chain of your choice to create Program advances during a sequence:

[D]	Enables entry of a Program chain number.
[7]	"7" is the number (selected from possible 0 to 9) of the program chain that contains the sounds you want to use in this sequence, loaded in the proper order.
[ENTER]	Enters your selection (7); display shows first program in the chain.
(SEQUENCE)*	*(Light must be ON).
(1)	Call up sequence in location 1.
(EDIT)	Goes to EDIT mode.
(START)	Sequence 1 will play back one time. During this playback, press the A (advance) button at the time(s) a Program chain advance (change of sound) is required. With each advance, you will progress to the next sound in program chain number 7 (in this case).
[D]	(Exits this routine.)

TO PLAYBACK A SEQUENCE WITH PROGRAM CHAIN ADVANCES:

[D]	"P" for "play" in display; (if not, [D] again).
[7]	Specifies Program chain number 7.
[ENTER]	(Resets Program chain 7 to its beginning).
(SEQUENCE)	Enable sequence mode.
(1--6)	Call up (one) sequence location from 1-6.

(RECORD light OFF).

(START)	Sequence 1 plays with Program advances you requested in the order you (previously) specified for the Program Chain selected (7). If you don't know how to load a Program chain, see below:

(LOADING A PROGRAM CHAIN: PROCEDURE)

[C], [8]	This entry reveals the status of system security that prevents unauthorized tampering with program chains. Check the display; if you see:

"DISABLED" -- enter the factory-supplied code 0000 (or your 4 digit code if you have changed it) and [ENTER].

"ENABLED" -- [ENTER], [ENTER] and continue:

[D]	"P" for "play" in display (do not want this mode).
[D]	"L" for "load" (leave "L" in display).
[7]	Specific chain number you wish to put into some order. (Choices from 0 to 9).
[ENTER]	
[xx]	Enter, using the keypad the number ("xx") of the first program you want to load into the program chain.
[ENTER]	Records that number (the number in the display.)
[A]	(Hit the A button, to advance to next chain location.)
[xx]	Enter the number of the second program you want to appear in the chain.
[ENTER]	Enters that number.

[A] Advance in chain.

REPEAT PROCEDURE TO LIMIT OF 20 PROGRAMS PER PROGRAM CHAIN. Automatic spillover to next higher-numbered program chain will occur. (Can use fewer than 20 programs of course). For final program, no need to [A] to advance.

[D] This step tells the computer where the chain is to end.

IF YOU MAKE AN ERROR LOADING A CHAIN OR WISH TO REPLACE A PROGRAM, SEE YOU OWNER'S MANUAL, PAGE 21.

Comment: It is important to understand how a Program advance occurs within a sequence. Using the routine in this tutorial, you store only advances, NOT calls for specific sounds. For instance, if you have certain sounds in Program Chain 7 that make sense with a sequence, and you now tell that sequence to use Program Chain 8 instead, the Memorymoog Plus will dutifully start at the first Program of Chain 8 and advance when told to. The sounds produced will depend on those found in Chain 8, in whatever order they happen to be.

Also, be aware that you must mechanically enter the desired Program chain you want before playing a sequence. Sequences do not "remember" which Program chain you have in mind. If you tell the Memorymoog Plus to play a sequence without specifying a program chain, it will do so WITHOUT supplying program advances you may have programmed. YOU MUST PRESS [D], ENTER THE PROGRAM CHAIN NUMBER, AND PRESS [ENTER] BEFORE STARTING A SEQUENCE IF YOU WISH TO HAVE PROGRAM ADVANCES DURING THE SEQUENCE.

In short, the Program advances within a sequence are simply advances, not stored program numbers, or linkages to a specific Program chain. They make sense if you set up the appropriate Program Chain and order programs within it. Then you must specify that Program chain before playing the sequence if you want program advances during the sequence.

In fact, you can set up several advances within a sequence and experiment with the programs within the specified program chain afterward. The times that an advance occurs remain, but the specific program the instrument advances TO is up to you.

THIS ENDS THE "PROGRAM ADVANCES DURING THE SEQUENCE; TONE-COLOR ON-THE-FLY" TUTORIAL.

MERGE--GROUPING SEQUENCES: A TUTORIAL

Once you have created several sequences you may wish to "merge" them into a song or composition. It is possible to specify which sequences will be used, their order (numbers may be repeated), and the number of times a sequence "loops," or repeats.

You can create three merges and store them in SEQ/MERGE locations

1-3.

An important facet of creating a merge is specifying the Program chain number that will account for Program advances during the merge. If you run out of Program chain space (20 positions), you will simply spill over into the next higher numbered Program chain. That is, if your merge uses 36 Program advances and you start on chain 7, you will fill all 20 locations of chain 7 and fill 16 of chain 8.

Unlike sequences, however, a merge DOES remember which Program chain to call up. In fact, this is the first piece of information you must specify when making a merge. Since you may spill over into a higher chain, in cases where you might use all three merge locations (1-3), we suggest you use chains 5, 7, and 9 to allow spillover to the next higher chains 6, 8, and 10 respectively. Let's look at the basic format for creating a polyphonic merge:

THE POLYPHONIC MERGE --

(SEQUENCE mode)

(MONO light OFF)

(MERGE)	MERGE light ON; (SEQUENCE light OFF.)
(1)	Merge location 1 selected (1-3 available).
(RECORD)	Record mode.
(START)	Begins prompts.
"PRGCHN"	Display asks for Program chain number.
[7]	Program chain 7 is selected.
[ENTER]	Enters number in display (7).
"SEQ"	Asks for number of sequence you want played first.
[1]	Sequence number 1 selected to appear first.
[ENTER]	Enters number in display (1)
"LOOPS"	Asks how many times you want the sequence just specified to repeat, or loop (max=9).
[2]	(Play it twice).
[ENTER]	Enters number in display (2).
"SEQ"	Asks which sequence is to be played next.
[4]	Selects sequence number 4 to be played next.

[ENTER]	Enters number in display (4).
"Loops"	Asks how many times to play sequence just specified.
[3]	(Play 3 times).
[ENTER]	Enters number in display (3).

THE "SEQ--LOOPS" cycle may be repeated 40 times. Obviously sequence numbers can be repeated (in any order). The maximum number that can be entered for "LOOPS" is 9. When you complete this cycle to your satisfaction, then:

⟨STOP⟩	Display reads "END".
⟨RECORD⟩	Disable Record mode (light OFF) so you can playback.

THE MONOPHONIC MERGE

If you want the mono merge to synchronize with the poly merge, take care to enter the numbers for "SEQ" and "LOOPS" in mono merge that you did in poly merge. The entry procedure is almost exactly the same as above. For MONO MERGE:

⟨MONO⟩	Put MONO light ON.
⟨MERGE⟩	Merge mode enabled.
⟨RECORD⟩	Record mode enabled.
⟨1--3⟩	Select mono Merge location (same as poly merge if synchronization is desired).
⟨START⟩	Prompts "SEQ" and "LOOPS" as in poly merge above. Respond by entering number(s) on keypad and [ENTER].
⟨STOP⟩	Display reads "END."
⟨RECORD⟩	(Turn Record light off).

TO VERIFY PLAYBACK OF POLY/MONO MERGE

⟨START⟩	As a visual aid, during playback of a poly/mono merge, the MONO light will toggle (alternate) ON and OFF. When it is on, the light of the mono sequence location currently playing will be on. When MONO light is off, this is the poly mode; the poly sequence currently playing

will come on. By observing the MONO light, you can tell which poly, and which mono sequence is playing at the moment.

THIS ENDS THE "MERGE--GROUPING SEQUENCES" TUTORIAL.

STEP MODE POLY RECORD/PLAYBACK: A TUTORIAL

In this mode you may enter notes/chords one-at-a-time into the sequencer memory to create a sequence:

Place the switch on the back panel to the STEP position, and connect a footswitch to CLOCK IN. (Or press the STEP switch when told to press footswitch).

Connect CLICK OUT to your amplifier.

Access the "SEQUENCE" mode: [C], [C], [ENTER].

(BE SURE MONO LIGHT IS OFF. IF NOT, ⟨MONO⟩.

⟨RECORD⟩	Enables Record mode.
⟨1--6⟩	Selects a sequence locaation.
⟨START⟩	(Prompts)
"TEMPO xx"	"xx" value displayed may be any value or character, depending on any previous recordings done. As you use the keypad to key in the new value, verify by watching the display.
[0], [0]	Press zero twice; a zero TEMPO value puts the instrument into the STEP mode. It is not necessary to enter 00 for tempo unless you are using the STEP button in lieu of footswitch.
[ENTER]	
"BEATS"	Your choice here determines the number of clicks you will hear per measure. In general, select the highest number available for duple time (8), or triple time (6), since this value can be edited later to a lower beat rate, thereby speeding up the passage. If you enter "4," there will be four clicks per measure; if "8," there will be eight. (Eight clicks per measure).
[8]	
[ENTER]	

"VOICES"	Enter the number from 1-6 you would like to use.
[6]	Six voices to be used.
[ENTER]	
"START"	
(START)	

THE FOLLOWING IS THE GENERAL ENTRY PROCEDURE:

DEPRESS AND HOLD FIRST CHORD/NOTE.

"MEAS 1"

DEPRESS FOOTSWITCH (OR (STEP)).

RELEASE FIRST CHORD/NOTE.

DEPRESS FOOTSWITCH (OR (STEP)).

REPEAT PROCEDURE FOR NEXT CHORD/NOTE.

Comment: If you repeat the general entry procedure four times, you produce a single bar of 4/4 with eighth notes sounding on the beats, separated by eighth rests--"8 beats" as you programmed in the tutorial. In this case, the CLICK OUT coincides with eighth notes.

Does this mean you can enter an event for each eighth note slot? Yes and no. Yes, if you don't play the same event (chord or note) twice consecutively. If you simply depress the footswitch (or (EDIT)) once for each event, the second of two identical chords will NOT be articulated. That is, IF YOU DO THE FOLLOWING PROCEDURE USING THE SAME CHORD:

(SAME CHORD PROTOCOL)

1. Play/hold (SAME) chord.
2. Depress footswitch or (EDIT).
3. Repeat steps 1-2, eight times.

THEN YOU WILL CREATE A WHOLE NOTE (COMPLETE MEASURE) OF THAT CHORD (8 eighth notes); you will not create eight separately articulated chords. Only when you "leave a space" by depressing the footswitch (or (EDIT)) with NOTHING played on the keyboard do you assure that the next event will receive a new trigger, creating a new articulation.

On the other hand, if a chord is DIFFERENT from its predecessor, articulation will occur as a natural function of the "voice

reassignment" Memorymoog Plus keying scheme. THAT IS, IF YOU FOLLOW THIS ROUTINE, USING DIFFERENT CHORDS:

(DIFFERENT CHORD PROTOCOL)

1. Play/hold (DIFFERENT) chord.
2. Depress footswitch or (EDIT).
3. Repeat steps 1-2, eight times.

YOU WILL CREATE EIGHT EIGHTH-NOTE CHORDS--A FULL MEASURE WHEN "BEATS 8" IS SELECTED.

To create eighth-note measures using a repeated chord, program with "BEATS 8" and edit to "BEATS 4" for playback. This effectively doubles the tempo, without actually altering the "TEMPO" prompt value. (Technically, the instrument will indicate that TWO measures will be required.

(STOP)	Defines end of sequence.
"END"	

REMOVE FOOTSWITCH FROM CLOCK IN INPUT. (CLOCK IN jack must not be in use if internal clock is to be used to playback sequence).

(EDIT)	Go to Edit mode in order to enter a playback TEMPO value.
(RECORD)	Prepare to record edits.
(START)	Prompts.
"TEMPO 00"	Current TEMPO value.

ENTER YOUR TEMPO VALUE ON THE KEYPAD, e.g.:

[1], [5], [0]	(150)
[ENTER]	Enters your value.
"BEATS 8"	Current value. Enter 4 to provide playback that is twice as fast as value of 8.
[4]	
[ENTER]	Enters your value.
"VOICES 6"	Current number of voices allocated to sequencer.
[ENTER]	Enters current value.

"START"

⟨START⟩ Starts sequence playback.

⟨STOP⟩ Stops sequence playback.

TO CHANGE TEMPO OR OTHER PROMPT VALUES, RETURN TO THE EDIT MODE:

⟨EDIT⟩

⟨RECORD⟩

⟨START⟩

AND FOLLOW PROTOCOL AS ABOVE.

THIS ENDS THE "STEP MODE POLY RECORD/PLAYBACK" TUTORIAL.

STEP MODE MONO RECORD/PLAYBACK: A TUTORIAL

ASSUME THAT POLY SEQUENCE HAS BEEN ENTERED USING STEP MODE.

LEAVE FOOTSWITCH IN CLOCK IN JACK ON BACK.

⟨MONO⟩ Light ON.

⟨RECORD⟩ Enable record mode.

⟨1--6⟩ Select a location number.

⟨START⟩ (Prompts for TEMPO and BEATS as above. [ENTER], [ENTER].)

"START"

⟨START⟩ As you depress the footswitch, the polyphonic sequence just recorded will be played back (stepped one event per footswitch depression). At the same time, a monophonic stepped-sequence can be recorded. Enter a mono sequence for the same number of measures as the poly sequence.

⟨STOP⟩ (When finished.)

⟨RECORD⟩ Disable Record mode.

⟨START⟩ Step through sequence with footswitch. To use internal clock to playback sequence(s), see above.

⟨STOP⟩

"END"

THIS ENDS THE "STEP MODE MONO RECORD/PLAYBACK" TUTORIAL.

VOICE ALLOCATION: SOME SUGGESTIONS

When you are prompted to enter a value for VOICES, you may choose less than 6 and have voices available to play on the keyboard in conjunction with a sequence.

When you allocate 5 to the sequencer and only 1 to the keyboard, put the MONO switch (upper left) of the Memorymoog Plus ON. This prevents "losing" notes due to what would normally (without using sequencer) be a polyphonic "note robbing" scheme.

TRANSPOSING USING THE KEYBOARD

A poly sequence will be transposed by a mono sequence when the MONO light in the MODULATION/SEQUENCER section is ON, and the HOLD light is ON. You must also strike the keyboard once after the HOLD light is ON to enable this capability. This is useful if you would like to repeat blues changes, for instance. Play the poly riff in one key. Program the mono sequence to feature I, IV, and V scale degree changes at appropriate timing.

Transposition from the keyboard is possible as well. The MONO light in the SEQUENCER section should be OFF. Put the HOLD light ON after sequence has been called up. Assume that middle C is "zero," or no transposition. Play any interval above/below middle C to cause poly sequence to be transposed. Obviously you do not play the keyboard polyphonically in this mode! In some cases, if you go from using a mono sequence as the transposer, to using the keyboard as the transposer, you will have to toggle HOLD OFF then ON to have the function operate.

TIDBITS

Take note that the mono sequence will be heard only if the external instrument is connected to the Memorymoog Plus properly, AND only when the KD OUT light is ON. When playing poly and mono sequences together in a merge, take care to reprogram the poly programs to have this light ON if you want to enable the external instrument during a sequence or merge.

SEQUENCER JACKS ON REAR PANEL

START/STOP -- Starts/stops sequencer. A footswitch inserted here acts in lieu of the START/STOP switch on the front panel.

CLOCK IN -- Accepts external clock, such as a clock track recorded on audio tape in the recording studio, or the clock output of a drum machine. This jack works in conjunction with the STEP/LOW/MED/HIGH

switch. In the step mode a rising edge advances the clock one step. The other (rate) positions are used to interface to a variety of external devices such as drum machines that may have different clock rates.

CLOCK DISABLE -- Stops yo' clock! Stops the Memorymoog Plus sequencer clock without resetting it to the beginning of a sequence.

CLICK OUT -- Provides an audible click when monitored to assist when you are recording sequences. Clicks are synchronous to beats per measure as programmed by performer.

CLOCK OUT -- Provides a 100 microsecond pulse at 96 cycles per measure. May be recorded on a single track of a multitrack tape recorder to provide a master clock for synchronizing many sequences performed on the Memorymoog Plus. May be used to drive a drum machine, sequencer, etc.

MIDI CONNECTORS ON REAR PANEL

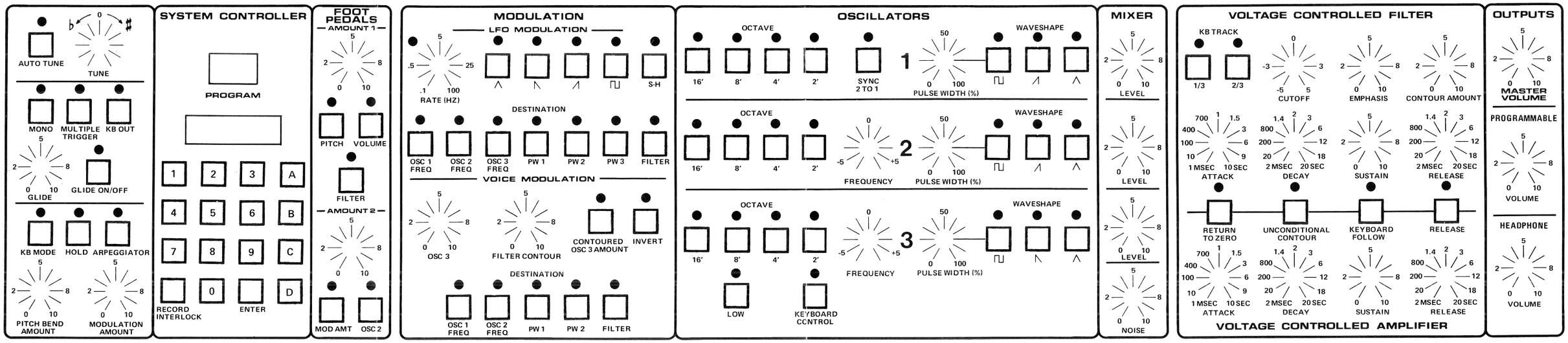
MIDI IN -- Input for MIDI. Connect the MIDI output of another instrument to this connector if you want the Memorymoog Plus to be slaved to the other instrument.

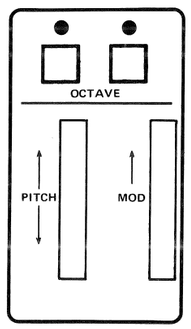
MIDI THRU -- A simple bypass that provides another version of any signal applied to MIDI IN. This connector allows you to "chain" several instruments without causing a slowdown of keyboard keying information.

MIDI OUT -- Provides Memorymoog Plus keyboard and Program number information to the external world. Connect this output to the MIDI input of an instrument to make the other instrument play the same notes you play on the Memorymoog Plus.


SYSTEM CONTROLLER
PROGRAM
FOOT PEDALS
MODULATION
LFO MODULATION
VOICE MODULATION
OSCILLATORS
MIXER
VOLTAGE CONTROLLED FILTER
VOLTAGE CONTROLLED AMPLIFIER
OUTPUTS
memorymoog
Synthesizer


HI-LEVEL AUDIO OUTPUT
BALANCED
UNBALANCED
FOOTPEDAL IN
EXTERNAL SYNTHESIZER OUT
CONTROL VOLT
1 VOLT/OCT
V-GATE
0 TO 15V
S-TRIG
15V TO 0
FOOTSWITCH IN
RELEASE
HOLD
PROGRAM ADVANCE
PROGRAM BACKSTEP
GLIDE
CLOCK IN
CASSETTE INTERFACE
FROM TAPE
REMOTE
TO TAPE
memorymoog
moog
120 VOLTS/60Hz
100 VOLTS/50Hz
110 WATTS
MODEL 345A
S/N 1012
POWER
OFF
ON
CAUTION
ATTENTION
MOOG MUSIC INC.
2500 WALDEN AVE.
BUFFALO, N.Y. 14225
MADE IN U.S.A.


AUTO TUNE
TUNE
MONO
MULTIPLE TRIGGER
KB OUT
GLIDE
GLIDE ON/OFF
KB MODE
HOLD
ARPEGGIATOR
PITCH BEND AMOUNT
MODULATION AMOUNT
SYSTEM CONTROLLER
PROGRAM
1
2
3
A
4
5
6
B
7
8
9
C
0
D
RECORD INTERLOCK
ENTER
FOOT PEDALS
AMOUNT 1
PITCH
VOLUME
FILTER
AMOUNT 2
MOD AMT
OSC 2
MODULATION
LFO MODULATION
RATE (HZ)
S-H
DESTINATION
OSC 1 FREQ
OSC 2 FREQ
OSC 3 FREQ
PW 1
PW 2
PW 3
FILTER
VOICE MODULATION
OSC 3
FILTER CONTOUR
CONTOURED OSC 3 AMOUNT
INVERT
OSCILLATORS
OCTAVE
16'
8'
4'
2'
SYNC 2 TO 1
1
PULSE WIDTH (%)
WAVESHAPE
2
FREQUENCY
3
LOW
KEYBOARD CONTROL
MIXER
LEVEL
NOISE
VOLTAGE CONTROLLED FILTER
KB TRACK
1/3
2/3
CUTOFF
EMPHASIS
CONTOUR AMOUNT
1 MSEC
10 SEC
ATTACK
2 MSEC
20 SEC
DECAY
SUSTAIN
RELEASE
RETURN TO ZERO
UNCONDITIONAL CONTOUR
KEYBOARD FOLLOW
VOLTAGE CONTROLLED AMPLIFIER
OUTPUTS
MASTER VOLUME
PROGRAMMABLE
VOLUME
HEADPHONE
VOLUME


OCTAVE
PITCH
MOD